REPORT

DOOSAN ENERBILITY CO., LTD.

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Design Advice on Fish Passages for the Upper Trisuli-1 Hydropower Project test

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REPORT

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Design Advice on Fish passages for the

Upper Trisuli-1 Hydropower Project

This report describes the design advices on the fish passage for the UT-1 Hydropower project as requested by DOOSAN ENERRBILITY Co., LTD. Nepal Water and Energy Development Company (NWEDC) is the developer of this 216 MW hydropower plant in Rasuwa District of Nepal.
The report provides recommendations to the detail design of the fish passages. Preparation has been carried out in cooperation with Sanima Hydro and Engineering Pvt. Ltd. in Nepal..

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1 Introduction

The 216 MW upper Trishuli-1 Hydropower Project is located in the Rashuwa District of Nepal. It is a run-of-the-river project. The development includes a 21 m high diversion dam structure located in the river at El. 1238. Water is withdrawn and utilized in a powerplant located some 10 km downstream before fed back to the river. Mitigating measures are planned so as the up- and down migrating fish are able to pass the hydropower facilities.

Developer is the Nepal Water & Energy Development Company Private Limited (NWEDC). Doosan Enerbility Co., Ltd. is the EPC Contractor of the project and the Client of Sweco Norway. Sweco Norway has prepared this report as part of the services to finalize the detail design of the UT-1 fish ladder in cooperation with Sanima Hydro and Engineering Pvt. Ltd. in Nepal.

2 Recommendations to the fish passages design

The main purpose of the fish passages is to keep the ecological corridor open for up-and downstream migration of the target species Snow trout (Shizothorax richardsonii).
The principals and practical advices are to a large extent given in the fish ladder report from 2018 (Kaasa and Almestrand 2018): "Design Advice on Fish Ladder and Associated Spillway Designs at the Upper Trisuli-1 Hydropower Project"

In the present report details and measures linked to up-and downstream migration are presented.

A) Fish species

The overall dominant species in the UT-1 area of Trisuli is Asala (Shizothorax richardsonii) which is the target species for development of the design and functionality of the fish ladder. Other fish species that are able to pass through rapid waters as titae or Stone carp (Psilorhynchus pseudecheneis) and some cat fish species might also be able to benefit from the fish ladder services.

B) Functionality

When examining the upstream migration of Snow trout it seems to be spring time that is the most potential period. But since snow trout are spawning both during springtime March/April, and during late monsoon September/October it is reasonable that upstream migration take place during the monsoon period. How these migrations take place in Trisuli is not clearly documented, but our results from local investigations along the Trisuli river basin indicate that Snow trout spawning occur in the tributaries during springtime. If spawning activity also happen during late monsoon is not documented, but Information from local fishermen upstream of UT 1 indicate that adult and quite large Snow trout normally entered this river section during monsoon.

Trisuli is a snow and ice fed cold river, and water temperatures might influence the upstream migration of fish as the physiological ability to perform high level burst speed normally is connected to the water temperature.

Investigations in Trisuli during the clear water period showed very low densities of Snow trout compared to what was recorded in the warmer tributaries, and that presence of fry

and young fish was almost absent in the main river. It seems likely that Snow trout forms local populations connected to the warmer tributaries, and that the main river to a great extent serve as migrating corridor while the tributaries serve good habitats for spawning and nursing.
There is not available data showing the exact timing and magnitude of the migration activity of Snow trout in Trisuli, so until more hard facts are available it is reasonable that the fish passage should be in function for all normal flows. If later on the investigations show that there are periods with no upstream or downstream fish migrations, the fish passage measures can be closed during these periods.

Natural flow fluctuations do normally give changes in upstream migrating conditions and an ecological corridor might occasionally be naturally closed due to changes in the physical conditions.
For the upper Trisuli -1 fish ladder it seems reasonable according to the target species behaviour and life strategy, that the functionality should be in place up to at least average Monsoon Flow which is a river flow of 411m3/s. Deducted a turbine flow of Q = 76 m3/sec, the resulting flow entering the river downstream of the dam will be Q = 335 m3/sec.

For river spawners the downstream fish migration of adult fish do normally occur some time after spawning are finished. This group of fish with high number of eggs usually has a downstream dispersal strategy, which means that eggs and newly hatched fry are drifting downstream during period after spawning.

C) Flow through the fish ladder for upstream migrating fish

During the low flow season the e-flow release is close to Q = 4 m3/s. This e-flow are used to obtain good conditions in the fish ladder and is distributed as follows :

- Q = 1 m3/sec trough the fish ladder from the top
- Q = 3 m3/sec is introduced in downstream entrance section via a bypassing auxiliary pipe

The resulting attraction water flow leaving the fish-ladder is Q = 4.0 m3/sec.

D) Height difference between the pools in the fish ladder.

The height difference between the pools in a fish ladder is a crucial parameter, and should be decided on basis of knowledge about the strength of the species present. For UT-1 fish ladder it is the target species; Snow trout (Shizothorax richardsonii), that give the basic conditions. Snow trout is strong and has jumping skills that allow this species to migrate far upstream in rapid cold rivers, and is found up to 2800 masl. (Kaasa, H and Rivinoja, P. 2023). .
Snow trout (Shizothorax richardsonii) have powerful streamlined bodies and are adapted to rapid and cold water. The species living in this kind of environment have normally developed higher swimming speed than fish living in lentic areas. It is assumed that Shizothorax richardsonii can perform a burst speed of approximately 3,5m /s.(Kaasa, H. and Rivinoja, P. 2023).

The fish ladder design proposal of Doosan (2023.06.05) recommend an average pool difference of 0,15 m(ladder steps). This mean a low gradient in the fish ladder that is favourable for different fish species. In this UT-1 fish ladder where Shizothorax richardsonii is the target species, the 0,15m is probably an easy task for the fish to pass.

On the other hand a long fish passage as this UT-1 fish ladder might be a bit exhausting to pass and 0,15 m might give a fish friendly upstream route.
It is not only the steps of 0,15 m or higher that is crucial for the fish but also the water velocities in the steps and the relaxing conditions in between the burst speed performances that is decisive for the success of the fish ladder.
Another factor that normally are in focus are the total cost of the fish ladder. This is directly connected to number of pools and size of pools.

In the case of UT-1 fish ladder it's likely that Shizothorax richardsonii is able to pass steps higher than 0,3m, and has the ability to force water velocities more than 2m/s. To be able to pass more than 70 of these steps in a fish ladder the access to relaxing conditions in between the burst speed performances is crucial. The relaxing conditions should allow the fish to stay for some time in low energy surroundings until full recovery.

E) Downstream migrating measures at the weir

In the high flow period when the river flow exceeds flow for power generation and for environmental flow level, water will pass over the weir trough the installed gates. In this period it is reasonable that downstream migrating fish follow the main current downstream. To reduce mortality and damages on the fish population, it is recommendable to install a 2 m deep floating curtain with a net in lower part to guide the surface migrating fish to a flapped gate with a downstream fish friendly spillway. When the flow exceeds the capacity of the spillway flapped gate, it is favourable to use one of the radial gates to prioritize free flow before opening a second radial gate and so on for the third radial gate. The operation of these measures are restricted to the high flow season.

F) Downstream migration trough the desander basins

All year through the power generation flow passing the desander basins might carry fish, and in the periods after snow trout spawning also carry fry and eggs. To prevent fish from entering the power station and the Francis turbines, it is recommended to instal guiding measures in the desander basins.

3 The upstream migrating fish ladder – description

3.1 Summary

The fish ladder shall serve the upstream migration of the target species Snow trout (Shizothorax richardsonii). The total height of the fish ladder will be approximately 23 m depending on the location in the river of the entrance to the fish ladder (pool no 1). The first pool in the following concrete fish ladder is named pool no 2.

So far springtime is considered the most important migration period for the Snow trout, but since this species also has spawning time in the fall, the fish ladder must also be in function throughout the monsoon period

The exact total height of the fish ladder will be decided when the final location of the fish ladder entrance pool is settled. Recent information from Doosan show that a localization should be in the area of 1232 masl

The fish ladder is designed for a minimum environmental flow release of Q = 4 m3/sec of which Q = 1,0 m3/sec is fed into the concrete fish-ladder and the remaining Q = 3.0 m3/sec is introduced into the downstream fish-ladder section and into the entrance pool. The total attraction flow entering the river is Q = 4.0 m3/sec.

In detail the flow during low flow season is distributed like this:

- 1m3/s trough the concrete fish ladder from the top
- up to 0.5 m3/sec as attraction water added via the roof into the pool no 2
- 0,3 m3/sec as a small waterfall in front of the stop log opening at the outlet from pool no 2
- 2.2 m3/sec attraction water to the entrance pool (pool no 1) via pipes located on each side of this pool.

The very important properties of the entrance pool (pool no 1) is to be attractive for migrating fish, and to guide the fish to the entrance of the first step in the concrete fish ladder. This step is a stop log opening of 0,7 m with Δhw = 0.15m, and lead to pool no 2 in the fish ladder.
Pool no 3 has two vertical slot entrances with low Δhw = 0,1 m that is easy assessable for snow trout.

Due to the water level fluctuations during the high flow season the steps into the pools up to the annual average monsoon flow level shall be with two vertical slot entrances and a Δhw = 0,2 m. Data received from Doosan/Sanima indicate this level to be approximately 1235,5 masl.
Further upstream, except from the most upstream one, the remaining pools are of the type with overflow weir, each with steps of Δhw = 0.3 m. The pools are facilitated with resting slots and in between provided with larger resting pools.

The downstream sections of the fish ladder including pool no 1, are provided with a protective wall on the river side. It is likely that the discharge entering the river when operating the radial gates in the dam will bring a lot of sediment-deposits from the reservoir, and this wall is intended to serve as protection against sediment clogging and high-velocity water entering the fish ladder.

The vertical slot entrances in the lower fish ladder pools together with the upstream one (last pool at the weir) have the ability to accommodate larger swings in adjacent ponds (river and reservoir), and are easy accessible for Snow trout.

To ensure a flow with low turbulence and adequate energy conversation within the pools, a general requirement will be as follows :

Pools in which volumetric dissipated power should not exceed E = 150 to 200 W/m3.
Resting pools in which volumetric dissipated power shall not exceed E = 50 W/m3.

3.2 The entrance pool outside the fish ladder, pool no 1.

3.2.1 General

In principle, the entrance pool shall be attractive for Snow Trout. Substantial flow and spurt of water are qualities needed to attract this species.

The total (100%) e-flow during the dry season are designed to enter the entrance pool. Of this Q = 1.0 m3/sec is fish-ladder flow and the rest Q = 3.0 m3/sec is fed from the auxiliary pipeline.

Due to the narrow riverbed, the water level will probably fluctuate with high levels during monsoon. This might impose that the lower parts of the fish ladder during monsoon could be covered by water. This increased water level is of high relevance when designing the fish ladder and for the functionality of the fish ladder during monsoon.

The conditions in the river and in the pool outside the concrete fish ladder entrance is crucial for the functionality of the fish ladder.

A. The conditions in the river up to the outlet from the fish ladder must be adapted to the behaviour of the migrating fish species during the whole upstream fish migrating season.
B. The fish ladder entrance pool (pool no 1) shall be situated close to the upper part of the fish migrating section in the river.
C. Water velocity in the entrance pool (pool no 1) just downstream the first concrete pool (pool no 2), shall be no more than 0,6 m/s during the upstream migrating period.
D. The pool no 1 shall be equipped with some hiding-places for fish (big boulders)
E. The fish ladder should provide an entrance velocity of about 1m/sec as attraction velocity.
F. The attraction water from the auxiliary pipeline must not be supersaturated by air.

The entrance pool no 1 together with the downstream sections of the fish-ladder shall be sheltered by a concrete wall from high flows and high current velocities originated from the flow through the radial gates. This to prevent damage on the fish ladder entrance and to avoid bad conditions for fish, and also to prevent the pool being filled up by sediments. It is assumed that the radial gate flow will bring considerable amount of sediments previous deposited in the reservoir.

3.2.2 Description Entrance Pool

Ref. attached drawing -01, -03, -06, -07

The entrance pool is an excavated basin located adjacent the river course. It is approximately 24 m long measured along the centreline. Width varies between 9 m and 13 m. Floor is sloped and resulting max water depth is approximately 3.0 m. Some boulders are situated in deepest section of the chamber facilitating hiding spots for the migrating fish. The pool is framed by the excavated rock slope on one side and a protective wall on the river side. A boulder sill serve as the control unit.

As described in 3.2.1 B The fish ladder entrance pool (pool no 1) shall be situated close to the upper part of the fish migrating section.

Discharge from the entrance pool is fed into downstream river coarse and flow condition in this outlet area is dependent on existing river flow. During dry season this will equal min. flow release i.e. Q = 4.0 m3/sec. River flow beyond this will be effected by release from the dam.

Levelled river slope on the stretch Ch.200-Ch.330 is found as Is = 1/51.79. Release from the 2.5 m wide gate in the dam adjacent the power intake controlling the reservoir level may reach approximately Q = 12.0m3/sec subject to FSL at El.1255.0.

Assuming a river flow of Q = 4.0 m3/sec, the given M-number of M = 22.2 and uniform flow conditions subject to average river slope 1/51.79, estimated river velocity and water depth are as follows :

V = 1.2 m/sec
Yw = 0.23 m

Doing the same exercise with a river flow of Q = (12+4) = 16.0 m3/sec, the resulting velocity and water depth will be :

V = 2.0 m/sec
Yw = 0.53 m

The boulder sill in the outlet of the entrance pool (pool no 1) is approximately 10 m wide. It is assumed buried into the river ground and as a type where the gaps between the large boulders are closed. The boulders is assumed to consist of fieldstones. The sill is drowned by the river flow. Assuming Q = 4.0 m3/sec and ditto in the river, the sill is estimated to raise the water level by 0.075 m in the entrance pool.

If the entrance pool localisation as shall be decided by Doosan Enerbility is close to 1232 masl the protective wall must reach up to at least average monsoon flow level which might be close to 1235,5 masl. (HEC-Ras run with Q = 411.0 m3/sec)

The protective wall intends to protect the downstream section of the fishway from bed-load and high velocity flows during operation of the radial gates.

Total water flow entering the entrance pool is planned as Q = 4.0 m3/sec of which Q = 1.5 m3/sec is fed from the upstream pool 2 via a stoplog-opening (Δh = 0.15 m), and Q = 0.3 m3/sec from pool 2 roof via an overflow weir. This flow is a free falling jet entering the water surface in front of the pool 2 stoplog-opening.

The rest of the auxiliary flow, Q = 2.2 m3/sec, enters via two perforated transmission pipes located on each side of the entrance pool (no 1). These pipes are assumed with smooth surface and with dia. Ø 1.0 m. They are perforated with all together 125 nos of Ø 75mm drain-holes located in different positions. The purpose is to dissipate the Q = 2.2 m3/sec flow into air before entering all over the water basin.

Water volume in the pool no 1 is estimated to Vp = 570 m3 and Energy Dissipating Factor EDF = 197 W/m3. In this number, however, the energy loss effected by the air dissipation is not taken into account. We therefore consider the design to be reasonable regarding this requirement. .

Flow velocity in the largest transect is estimated to v = 0.11 m/sec.

3.3 Fish ladder pool no 2

3.3.1 **Description**

Ref. attached drawing -03, -06, -07

Pool no. 2 is located next to the entrance pool and is the first pool in the concrete fish-ladder.

The pool is with an area of A = 42.7 m2 and height h = 5.9 m. Inflow is Q = 1.0 m3/sec from the upstream located fish-ladder pool no 3, and Q = 0.5 m3/sec auxiliary flow from the above located distribution chamber at El. 1236 via drain holes in the roof structure. These holes are estimated to 8 nos sharp edged, each with diameter Ø 130 mm.

Flow in the pool no. 2 is controlled by a 0.7 m wide sharp-edged opening located in downstream wall. This opening is designed as a stop-log structure facilitating closure for maintenance reasons.

A hiding structure is located inside the pool. It consists of a wall reaching from floor up to the roof in this pool and is functional trough all flow conditions. Together with facilitating a resting slot, the wall serve as foundation for the roof and the pipe inlet structure.

Volume of water in the pool during low flow conditions is estimated to Vp = 107.8 m3. Flow velocity in the discharge from upstream located pool no. 3 is estimated to v = 1.4 m/sec (Q = 1.0 m3/sec and Δh = 0.1 m). Velocity in jet leaving the 130 mm roof-holes is estimated to v = 4.04 m/sec and the drop is Δh = 3.345 m. Volumetric rate of energy dissipation is estimated as follows :

EDF = (1*0.1*9.81*1000)/107.8 + (((4.04^2/19.62)+3.345)*0.5*9.81*1000)/107.8 = 199 W/m3. As for the entrance pool 1 the energy dissipation taking place in the air before the jet entering the water surface is not taken into account. We consider therefore the design is reasonable regarding this requirement.

Two vertical slots are the entrance to pool no 3. These vertical slots are with ability to accommodate downstream fluctuations (swings in river water discharge).

3.4 Fish ladder pool no 3

3.4.1 **Description**

Ref. attached drawing -03, -06, -07

Pool no. 3 is with horizontal cross section WxL = 4.7x5.0 and height is 2.5 m and is the second step-section in the concrete fish ladder

The flow in the pool is controlled by vertical dual slots incorporated into downstream cross wall structure, Δh = 0.1 m. Inflowing water is from pool no. 4 via vertical dual slots Water drop effected by this vertical slots is estimated to Δh = 0.2 m.

This vertical slot arrangement is with good ability to accommodate swings in downstream water levels.

The pool is provided with 2 nos hiding structures located on each side of the overflow weir. These are shown as concrete wall structures, but another material may be selected. Maintenance work will benefit with a demountable structure.

Water depth in the pool during low flow season is estimated to yw = 1.65 m and volume of water to Vp = 38.8 m3. The resulting volumetric rate of energy dissipation will be :

EDF = 50.6 W/m3 (< 150 W/m3).

Flow velocity through gross section of the pool is estimated to v = 0.13 m/sec.

3.5 Fish ladder pool no 4 and up to level 1235,5 masl

Ref. attached drawing -06, -07

Pool no 4 will have dual vertical slots as in pool no 3. Each of the two openings are with width w = 0.23 m. Estimated effected drop in water level subject to a flow of Q =1.0 m3/sec is Δh = 0.2 m. The pool is l = 4.0 m long and w = 3.0 m wide.

Water depth in the pool during low flow season is estimated to y_w = 1.8 m and volume of water to Vp = 21.6 m3. The resulting volumetric rate of energy dissipation will be :

EDF = 91.0 W/m3 (< 150 W/m3).

Flow velocity through gross section of the pool is estimated to v = 0.185 m/sec.

This pool configuration will be the same for all pools up to water level approximately 1236 masl. Having in mind the estimated EDF-number we do not consider it as reasonable to install resting-pools on this stretch.

The drawings show height of each cross wall h = 2.5 m. These pools are all with no roof and facilitated for fish to enter both through the vertical slots and also by entering directly into the submerged pool areas during monsoon. During monsoon the entrance pool will be less effective than during the low flow period, but still working well.

An assumed beneficial design worthwhile to consider in detail design will be to extend these cross walls to level the protective wall, thus providing support of this wall as well.

3.6 Pools above 1235,5 masl

3.6.1 Description

Ref. attached drawing, -05, -09, -10, -11, -12, -17, -18, -19

The pool type is provided with cross walls with a notched overflow weir controlling the water.

Main part of the fish ladder consists of this pool-type. Horizontal pool cross section is with length L = 4.0 m and width w = 3.0 m. The floor is sloped $\Delta h/\Delta l$ = 1/17.5 and with a drop of Δh = 0.1 m for every cross wall section.

Water drop effected by the notched overflow weir is estimated to Δh = 0.3 m. The overflow section alters between right and left position for every second pool.

Each cross wall have an A = 0.2mx0.2m sharp edged orifice located on floor level in the corner below the overflow weir. It is meant for draining the fish-ladder in order to facilitate maintenance work.

Each pool is provided with 2 hiding structures. These are shown as concrete wall structures, but another material may be selected. Maintenance work will benefit with a demountable structure.

The maximum velocity of the jet coming from the overflow section may be estimated to v = 2.4 m/sec. Assuming 1/3 of the head transformed to velocity head, the resulting velocity in the jet will be v = 1.4 m/sec which will be velocity when passing critical section.

Water depth in the pool is estimated to yw = 1.8 m and volume of water to Vp = 21.2 m3. The resulting volumetric rate of energy dissipation will be :

EDF = 138.8 W/m3 (≈ 150 W/m3).

Flow velocity through the cross section of the pool is estimated to v = 0.185 m/sec.

3.7 Resting pools

3.7.1 General

To ensure resting ability for migrating fish the fish-way arranged with overflow type of cross walls will be provided with resting pools.

3.7.2 Description

Ref. attached drawing -05, -12,.

The fish-way is provided with resting pools. On the downstream section, every 10’th pool is planned to be of this type. In the upstream section from pool no 30, the distance between each resting pool is reduced. The upstream section of the fish ladder is planned with this pool type for every 7’th pool.

Each resting pool is with a horizontal cross section of l = 5.2 m in length and w = 6.25 m in width. Floor is sloped downwards and have a 0.1 m drop at each cross wall section. Each cross wall is provided with an A = 0.2mx0.2m orifice located in the corner below the overflow weir on floor level.

The inflow is via a notched overflow weir and ditto the discharge. Drop in water level effected by each of these overflow weir is Δh = 0.3 m.

The resting pool is provided with all together 4 nos of hiding structures. These are shown as concrete wall structures, but another material may be selected. Maintenance work will benefit with a demountable structure.

Water depth in the pool is estimated to yw = 1.8 m and volume of water to Vp = 58.0 m3. The resulting volumetric rate of energy dissipation will be :

EDF = 50,0 W/m3 (50 W/m3).

3.8 Intake from the reservoir to the fish ladder

Ref. attached drawing -02, -04

The intake is incorporated into the dam structure and is a surfaced level and single opening intake. Water level fluctuations during fish-ladder operations are expected to be moderate. The intake which is the exit from the fish ladder shall be located as far away from the HP intake site as practically possible, and in an area where the water velocities in the reservoir are not more than 0,3m/s.

The intake is equipped with a stop-log structure followed by a main gate. Both the stop-logs as well as the gate may be used to control the inflow. The intake duct terminates in a cross wall of the vertical dual slots type.

The velocity in the exit transect from the fish ladder shall be no more than 0,7m/s. This to make it easy for migrating fish to enter the reservoir.

4 Auxiliary flow pipe arrangement

Ref. attached drawing -03, -06, -07, -08

An auxiliary flow of Q = 3.0 m3/sec is drawn from the reservoir and fed into downstream section of the fishway via a pipeline. Assuming smooth surface and length of this pipe to 200 m, estimated pipe diameter will be dia. Ø 0.7 m. Gross head from FSL at El.1255 down to water surface in the energy dissipator at approximately El. 1238 is 17 m.

To avoid confusing the fish leaving the fish ladder and formation of free surface vortices this auxiliary pipe intake is provided with a large rack opening (vdim ≤ 0.15 m/sec) and located away from the fish ladder opening and with adequate submergence (CL pipe ≈El.1250). (avoiding super saturated water entering entrance pool)

The pipeline is provided with 2 valves of which the upstream one is for maintenance purpose.

The flow leaving the pipeline is fed into an energy dissipation structure located upon fish ladder pool 3. Floor is located at El. 1236. From this energy dissipation chamber the flow is fed into a distribution chamber via an overflow weir. This chamber is located upon pool 2. From here the flow is dispatched into 4 directions :

- Q = 0.5 m3/sec is fed into pool 2 below via 8 nos Ø 130 mm holes situated in the roof structure
- Q = 0.3 m3/sec is passing via 2 notches and thereafter an overflow weir before entering the entrance pool water surface in front of the 0,7m stoplog opening from pool no. 2.

- Q = 2.2 m3/sec is disbursed into the entrance chamber via 2 pipes located on each side of the chamber. One is mounted on the protective wall and provided with 44 nos drilled holes, each with dia. Ø 75 mm. The other is mounted on the excavated rock surface on the opposite side and provided with 80 no of drilled holes with similar dia Ø 75 mm. Each main pipe is with dia. Ø 1.0 m.

It shall be mentioned that this described water flows are the situation during the low flow season. When water level increase the attraction water effect will be less effective but it will still be there even with high flow level up to 1236 masl.

5 High water level adaption

The fish ladder shall operate during the monsoon, and since the river bed is narrow, it is expected that the water level will rise during high water flows. These high flow water levels are of high relevance in the design of the fish ladder both due to how the fish might be able to find the fish ladder, and also at what level to localize the energy dissipiator.

If high water levels cause the lower parts of the fish ladder to become covered by water, both the entrance of fish and release of attraction water entails other conditions than during the low flow period. To keep reasonable good opportunities to detect the fish ladder and to be able to enter even on high flows, the pools in the fish ladder up to a flow level of 1236 masl is equipped by dual vertical slot entrances with $\Delta h = 0.2$ m, which is easily accessible for snow trout.

~~6~~ Management of the fish ladder

- High resolution flow data and temperature data will be good fish ladder management tools. The fish do not respond to average values of flow and temperature.

- Detection of the upstream fish migration seasons are important to investigate in order to decide the management plan, as for instance the operating periods of the fish ladder.
- The fish migrations are probably fluctuating between years and are probably related to temperature.

- To obtain a better knowledge about the fish migrations and the fish ladder functionality, it might be favourable to establish a monitoring program based on recording of fish in the fish ladder. This might be done by using the inlet flow control and to sample fish in the 0,2 x 0,2 m orifices in each pool.

- In a monitoring programme it is crucial to investigate if there is fish migrating upstream in the river along the river section from the area of tailrace and up to the entrance pool of the fish ladder.

- Inspection of the fish ladder should be done ones a year

7 Upstream migrating challenges not connected to the fish ladder

A fish ladder might be well designed and well-built but the success depends also on the conditions in the river downstream the fish ladder and of the technical solutions of the entrance area and exit area of the fish ladders.

- The confluence area between Trisuli river and the tailrace of UT-1 is a hot spot on whether the fish ladder will be successful or not. It should be assessed if necessary to implement measures to guide the migrating fish up and in to the river course instead of being aggregated in the confluence area.
- The dewatered river section should be examined for possible obstacles that might hinder upstream fish migration during the period of minimum flow release.
- The section of the river just downstream of the entrance to the fish ladder which was affected by the HP construction activity, and where the river substrate is affected, should be mitigated with large boulders which help to create hydraulic conditions for upstream fish migration. This is also a critical part of the river when it comes to getting a return on the investment in the fish ladder.

8 Downstream fish migration

When making an investment in an expensive fish ladder to keep the upstream eco-corridor open, it requires mitigating actions to also keep the sustainability of the downstream eco-corridor. If the mortality of downstream migrating fish is high, the eco-system services will suffer, and over a relatively short time span the fish population using this eco-corridor will be decimated or extinct. If the mortality of downstream migrating fish is high and if mitigation of these harmful effects has low success it is better not letting the fish migrate upstream through a fish ladder.

To prevent damage to the fish population, the following topics should be considered:

1) Water currents in the reservoir.
The main surface current entering the intake reservoir and the weir should preferably point at a downstream fish passage so as when there is overflow the water enter a fish friendly spillway and flow down to a soft landing in a downstream pool. To direct surface current to the fish friendly spillway a 2m deep floating guiding curtain is recommended.
When the river flow increase to a level where radial gates need to be operated it should preferably be given priority to free flow through one gate before the second gate are being used and so forth.
The reason is that adult fish probably migrate downstream in the main current near the surface during monsoon.
To avoid misunderstandings it should also be added that the measure with the guiding curtain in the reservoir during monsoon will probably not be a full effective measure, so measures in the desander basins is needed to be operated the whole year trough.
The guiding curtain in the reservoir is to prevent fish migrating trough the flapped gates at the top of the radial gates, that give high fish mortality. A fish friendly spillway will also give a better downstream passage for fish than to follow the flow through a partly open radial gate where the water will obtain very high velocities that together with high bed load probably will give substantial fish mortality.

A question raised is if the fish ladder might be an attractive point to enter for downstream migrating fish during low flow conditions. Due to the low flow in the fish ladder compared to the flow entering the desander basin, a fish ladder would not serve as a suitable downstream migrating corridor during that period.

2) Downstream fish passage

Ref. attached drawing -13, -14, -15, -16.

An important point is that fish migrating downstream across the weir should follow a fish friendly spillway and meet a soft landing in a downstream pool (see Sweco report of 15.08.2016, Fish Passage, evaluation of plans and recommendations, chapter 2.4).
When the flapped gates as designed at the top of the radial gates are used, they might serve as an opportunity for downstream migrating fish to pass over the weir. This will lead fish to fall 15 m and then hit the concrete basement. Heights above 5m will led to increased injurie and mortality. With a free fall of 15 m the fish will reach a velocity that even if hitting the water surface might cause high grade of injurie and mortality. To reduce the frequency of fish mortality due to passing through the flapped gates during monsoon, it is recommendable to use the flapped gates only short periods to empty for debris, and then to direct the excess water to a fish friendly spillway.

3) Tunnel entrapment
All year through, the fish that follow the flow to the desander basins will have low probability of survival. During low flow season and during early and late monsoon the challenge with this fish mortality is greatest due to most of the flow are passing through the power station. In these periods most of the downstream migrating fish, fry and eggs also follow the flow to the desander basins before they enter the HP tunnel and the point of no return. Francis turbines show relatively high fish mortality, but it is a hope that the small sized fry and eggs have a reasonable survival rate. To reduce this mortality significantly a possibility might be to prepare fish guiding mechanisms in the desander basins. In these basins, the water velocity is slow which normally give good conditions for building guiding mechanisms.

For more detailed information and discussions connected to the upstream and downstream migrations see the Sweco report of 15.08.2016.

Some general considerations:

- The natural mortality of eggs and newly hatched alevins are high under normal natural conditions.
- The mortality when fish are passing a Francis turbine depend on the turbine diameter, the frequency, how large openings there are between the turbine blades and the size of the fish .
- A mortality factor is also what tolerance the fish, fry and eggs has to the sudden drop in pressure that happened trough the turbine.
- The drifting of alevins and eggs do normally happened after spawning for eggs, and a period after hatching for alevins. In Trisuli this may mean during springtime and in late monsoon.

The eggs are passive drifting particles, and the alevins are also to a large extent depending on the water currents. This mean that the amount of eggs and alevins drifting into the desander basins probably are proportional to the relative water volume entering the basins. During

springtime only close to 4m3/s pass the weir as environmental flow through the fish ladder or as attraction water through a pipe to the fish ladder entrance pool. This makes it very challenging to guide the small sized eggs and alevins to the fish ladder entrance. It might be by a kind of filtration of water that in practical terms seems impossible.
During late monsoon the flow over the weir has a substantial higher value.

Because eggs and alevins are small, low grade of physical injurie are expected when passing through the turbines, and it might be reasonable to find relatively high survival rate on these small individuals. Reservations must be made regarding the tolerance for the effects of sudden drop in pressure.
Based on available information and knowledge, our recommendation is that guiding mechanisms for alevins and eggs are not recommended to be build. It is also worth mentioning that the young fish of 2 years or more and the adult spawning fish that has been through the periods of density dependent natural mortality is the most valuable fish when designing mitigating measures to reduce mortality.

When young fish and adults migrating downstream trough Francis turbines or through the flapped gates as designed at UT 1, the mortality are expected to be substantial.

9 Downstream fish migration measures

Ref. attached drawing – 13, 14, 15, 16 and Figure 1 in this report.

A new flapped gate with capacity 15m3/s and a fish friendly spillway for downstream fish passage is provided..
For the effectivity of the fish passage, a gate with higher flow capacity would be preferable. See Figure 3. See also the enclosed Drawings of flapped gate and spillway.

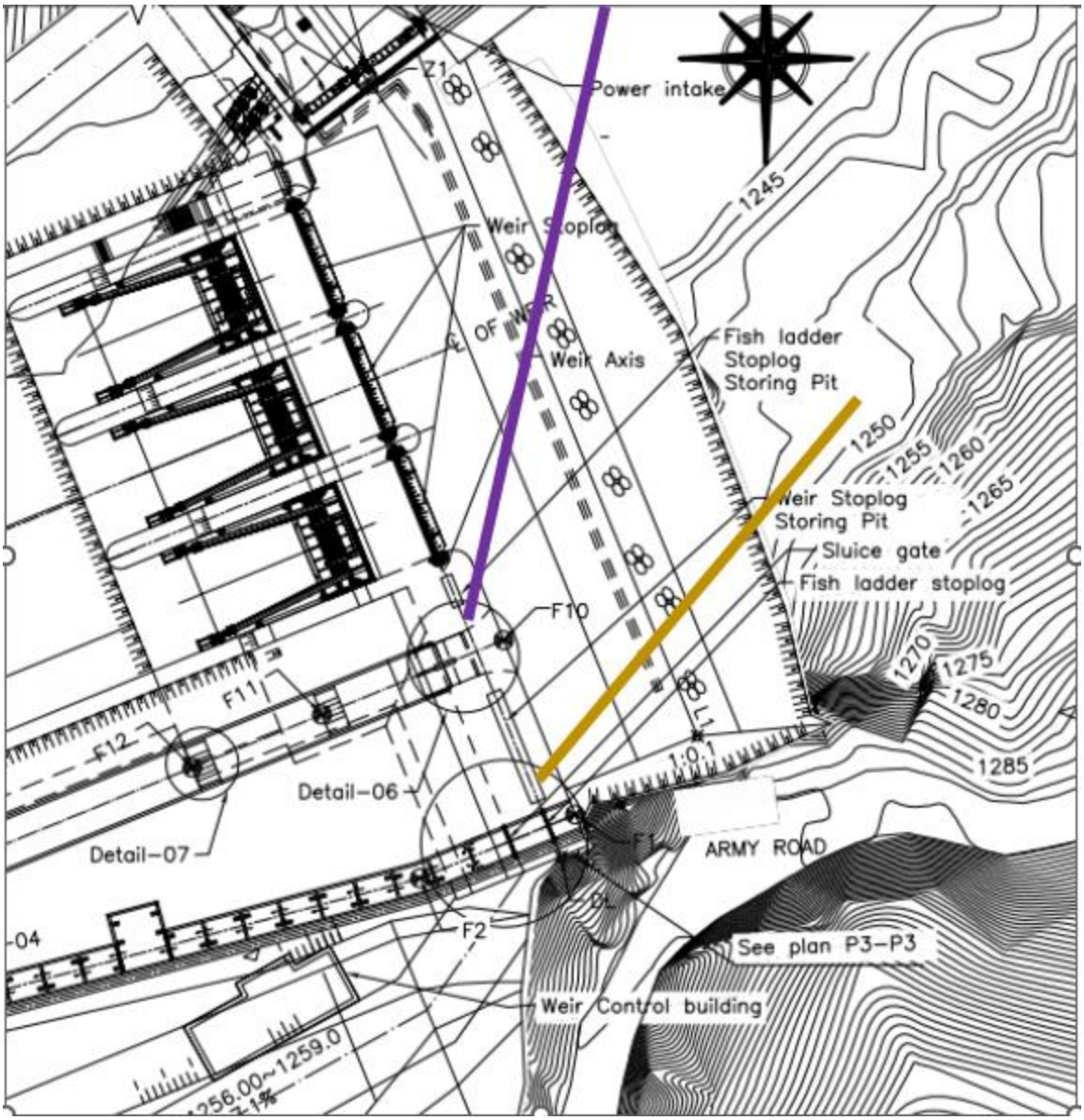


Figure 1 The weir with guiding measures.

Yellow line: An impermeable curtain to secure calm water for fish entering the reservoir from the fish ladder. The curtain cover the distance from the weir to the shore at the other side of the reservoir. The first 5 to 10 m of the curtain cover the water column from surface to bottom, the rest of the curtain is 2m deep and anchored to the bottom.

Purple line: floating curtain for guidance of fish to the spillway. The curtain is 2 m deep and the lower 1m can be made by a net with mesh size 10mm. The curtain must be made by a strong fabric so as it is possible to also guide debris to the spillway. The enclosed drawings show mor in detail the Flapped gate and the spillway.

10 Downstream fish migration measures in the desander basins

All year through the flow entering the desander basins will bring fish to this technical facilities where the water velocity is slow (less than 0,2m/s) which normally give good conditions for building guiding mechanisms.

The fish bypass concept has been discussed with Doosan and detailed drawings might be prepared if technical conditions in the desander basins make it possible to install this kind of mitigating measures.

The desander fish bypass plan discussed with Doosan is as follows:

1. Install a polymer net covering the desander transect from approximately the sediment surface to the top water level in a 30 degree angle. The aim is to guide fish towards the water surface and into a sampling cage or fish trap..
2. From the fish trap the only way out for the fish is through a water filled pipe (diameter= about 300mm) with flow like 0,1 -0,2 m3/s leading the fish back to the river. This pipe may be installed along the planned flushing access/maintenance tunnel, and the flow might be part of the environmental flow.

If these bypass solutions for fish in the desander basins are in question to install, Sweco can contribute in preparation of the detail design and give support in the planning process.

11 Literature

Kaasa, H. and Rivinoja, P. 2023. Swimming performance of Schizothorax sp. and planning of fish passages in Nepal. (in press).

Kaasa, H. 2016 Evaluation of plans and recommendations. Fish Passage, Upper T5risuli-1
Sweco report, no 3, 14685001

Kaasa,H, and Almestarnd, L.O. 2018 Design Advice on Fish Ladder and Associated Spillway Designs at then Upper Trisuli-1 Hydropower Project. Report no 4, 14685001

12 Attachments

Certification

Drawings

DRAWINGS

Certification

We hereby certify that the attached drawings prepared by SANIMA are in accordance with SWECO's design concept.

Oslo 10.11.2023

Leif Otto Almestrand

Leif Otto Almestrand

Halvard Kaasa

Halvard Kaasa

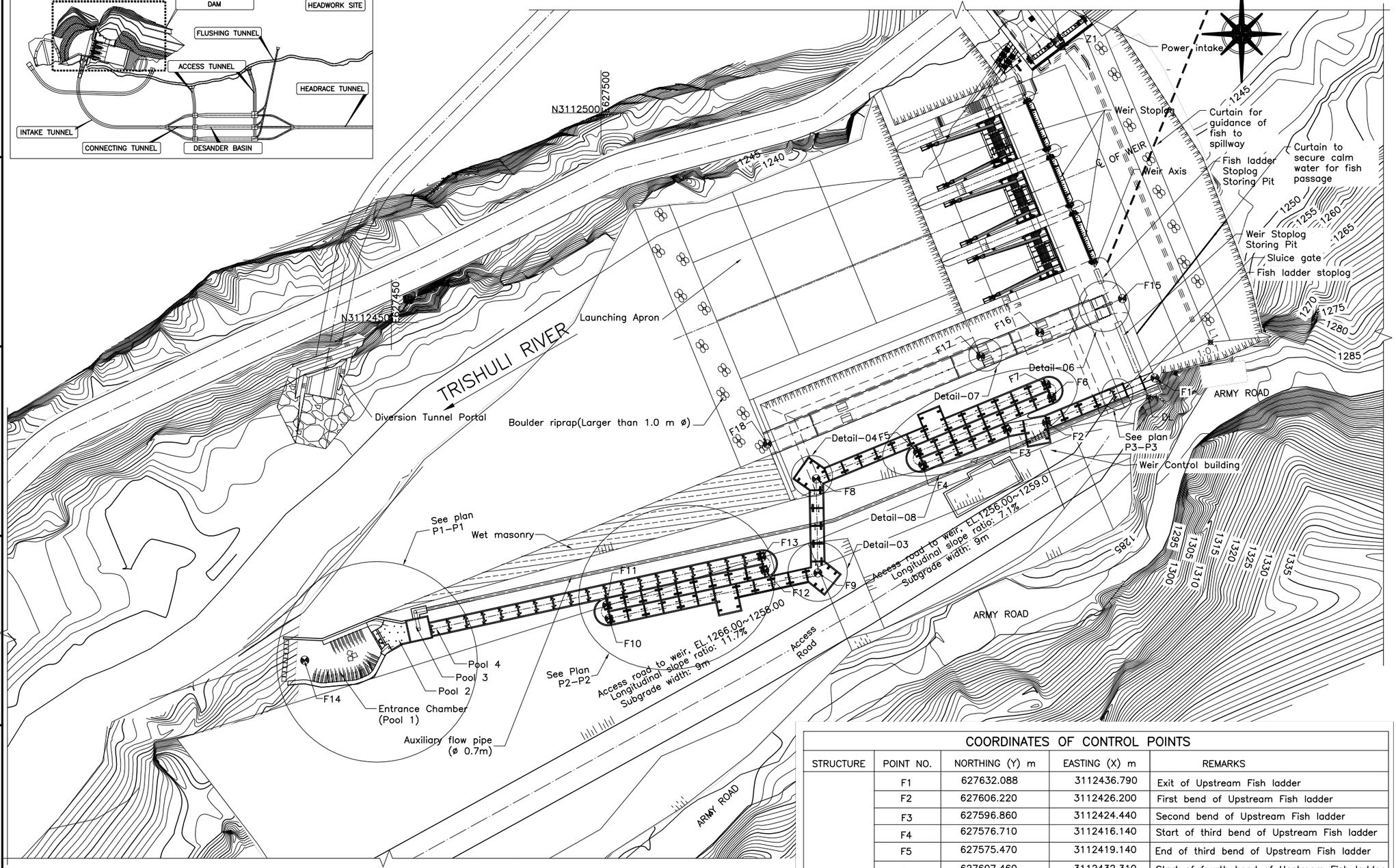
Upper Trishuli-1 HEP (216 MW)

DRAWING LIST

LAYOUT DRAWING OF FISH LADDER. Up-and Downstream Migration.

NUMBER	TITLE
UT1-C-050-CVL-DG-49001-01	PLAN. Overview
UT1-C-050-CVL-DG-49001-02	PROFILE. US Migration
UT1-C-050-CVL-DG-49001-03	PROFILE. US Migration
UT1-C-050-CVL-DG-49001-04	PLAN AND SECTION. US Migration
UT1-C-050-CVL-DG-49001-05	PLAN, PROFILE AND SECTIONS. US Migration
UT1-C-050-CVL-DG-49001-06	PLAN AND SECTION. US Migration
UT1-C-050-CVL-DG-49001-07	PLAN AND SECTION. US Migration
UT1-C-050-CVL-DG-49001-08	SECTIONS. US Migration
UT1-C-050-CVL-DG-49001-09	PLAN AND SECTION. US Migration
UT1-C-050-CVL-DG-49001-10	SECTIONS. US Migration
UT1-C-050-CVL-DG-49001-11	DETAILS. US Migration
UT1-C-050-CVL-DG-49001-12	DETAILS. US Migration
UT1-C-050-CVL-DG-49001-13	PLAN AND PROFILE. DS Migration
UT1-C-050-CVL-DG-49001-14	SECTION AND DETAILS. DS Migration
UT1-C-050-CVL-DG-49001-15	SECTION. DS Migration
UT1-C-050-CVL-DG-49001-16	SECTION. DS Migration
UT1-C-050-CVL-DG-49001-17	PLAN. US Migration
UT1-C-050-CVL-DG-49001-18	DETAIL. US Migration
UT1-C-050-CVL-DG-49001-19	DETAIL. US Migration

KEY PLAN



FISH LADDER LAYOUT PLAN

Scale 1:1000

COORDINATES OF CONTROL POINTS

STRUCTURE	POINT NO.	NORTHING (Y) m	EASTING (X) m	REMARKS
Upstream Fish ladder	F1	627632.088	3112436.790	Exit of Upstream Fish ladder
	F2	627606.220	3112426.200	First bend of Upstream Fish ladder
	F3	627596.860	3112424.440	Second bend of Upstream Fish ladder
	F4	627576.710	3112416.140	Start of third bend of Upstream Fish ladder
	F5	627575.470	3112419.140	End of third bend of Upstream Fish ladder
	F6	627607.460	3112432.310	Start of fourth bend of Upstream Fish ladder
	F7	627606.220	3112435.320	End of fourth bend of Upstream Fish ladder
	F8	627551.320	3112412.710	Fifth bend of Upstream Fish ladder
	F9	627551.720	3112390.300	Sixth bend of Upstream Fish ladder
	F10	627502.040	3112379.450	Start of seventh bend of Upstream Fish ladder
	F11	627501.340	3112382.630	End of seventh bend of Upstream Fish ladder
	F12	627539.050	3112390.860	Start of eighth bend of Upstream Fish ladder
	F13	627538.360	3112394.030	End of eighth bend of Upstream Fish ladder
	F14	627429.340	31123769.470	Start of upstream fish ladder
Downstream Fish ladder	F15	627624.336	3112455.715	Entrance of downstream fish ladder
	F16	627604.612	3112447.642	First drop of downstream fish ladder
	F17	627590.559	3112441.881	Second drop of downstream fish ladder
	F18	627539.663	3112421.035	Exit of downstream fish ladder

NOTE

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3. The flood wall arrangement provided adjacent to entrance pool of upstream fish ladder(at the left bank of river) is only for reference. the actual size of the wall shall be finalized after design.
4. The arrangement of the auxiliary flow pipe and anchor block is subjected to change as per the structural design of the fish ladder.
5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 10 0 10 20 30 40m

Scale 1:1000

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

FOR INFORMATION

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	SHG/SaP/DIS/DIP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC NEPAL WATER AND ENERGY DEVELOPMENT CO. (PVT) LTD.

OWNER'S ENGINEER

TRACTEBEL ENGINEERING GDF SUEZ | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

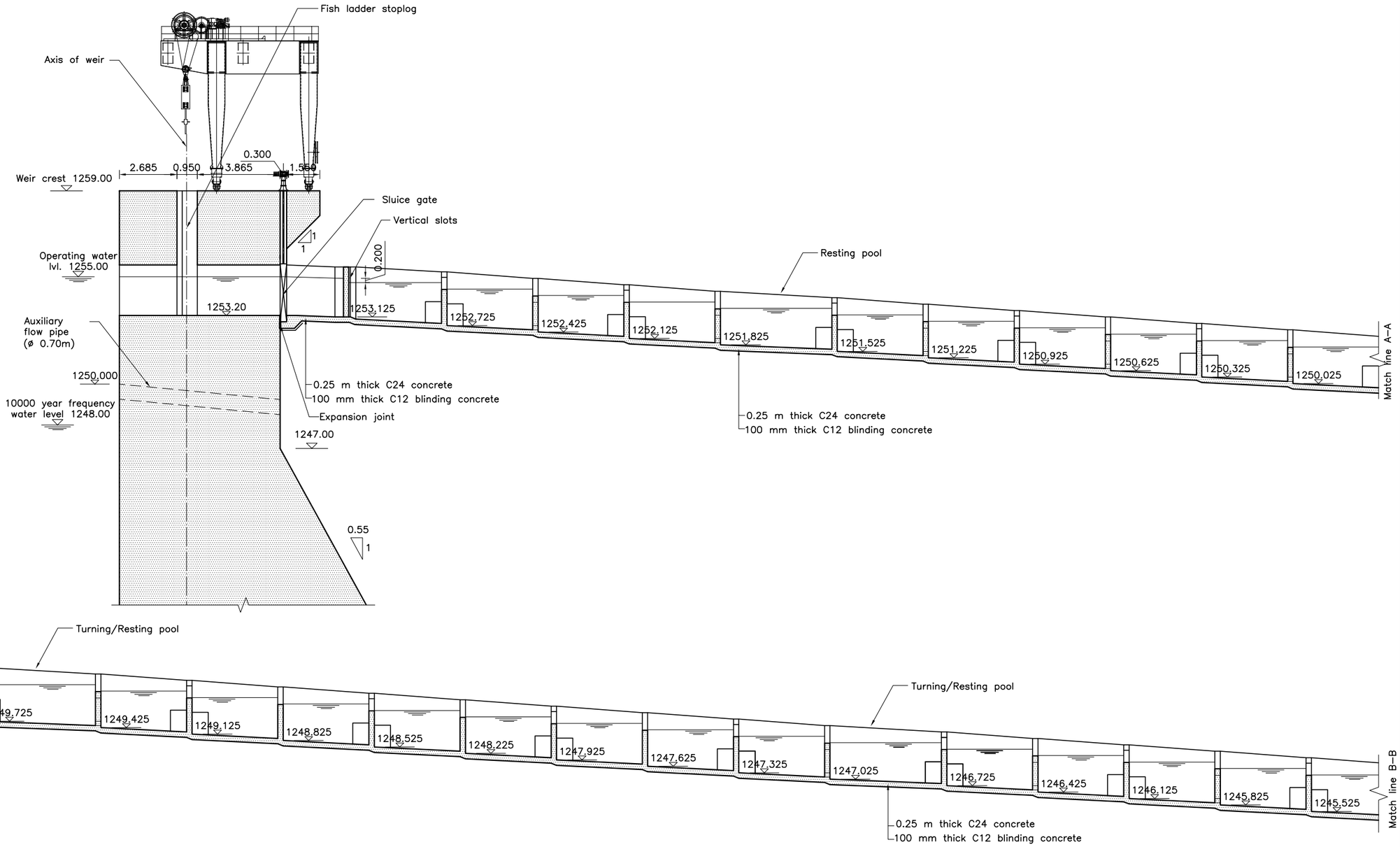
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

PLAN

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–01	01 OF 19	0A

A3 (297 x 420 mm)



LONGITUDINAL PROFILE OF FISH LADDER

Scale 1:200

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m 2 0 2 4 6 8 m

Scale 1:200

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PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGINEERING, jade CONSULT

CONTRACTOR

DOOSAN Enerbility

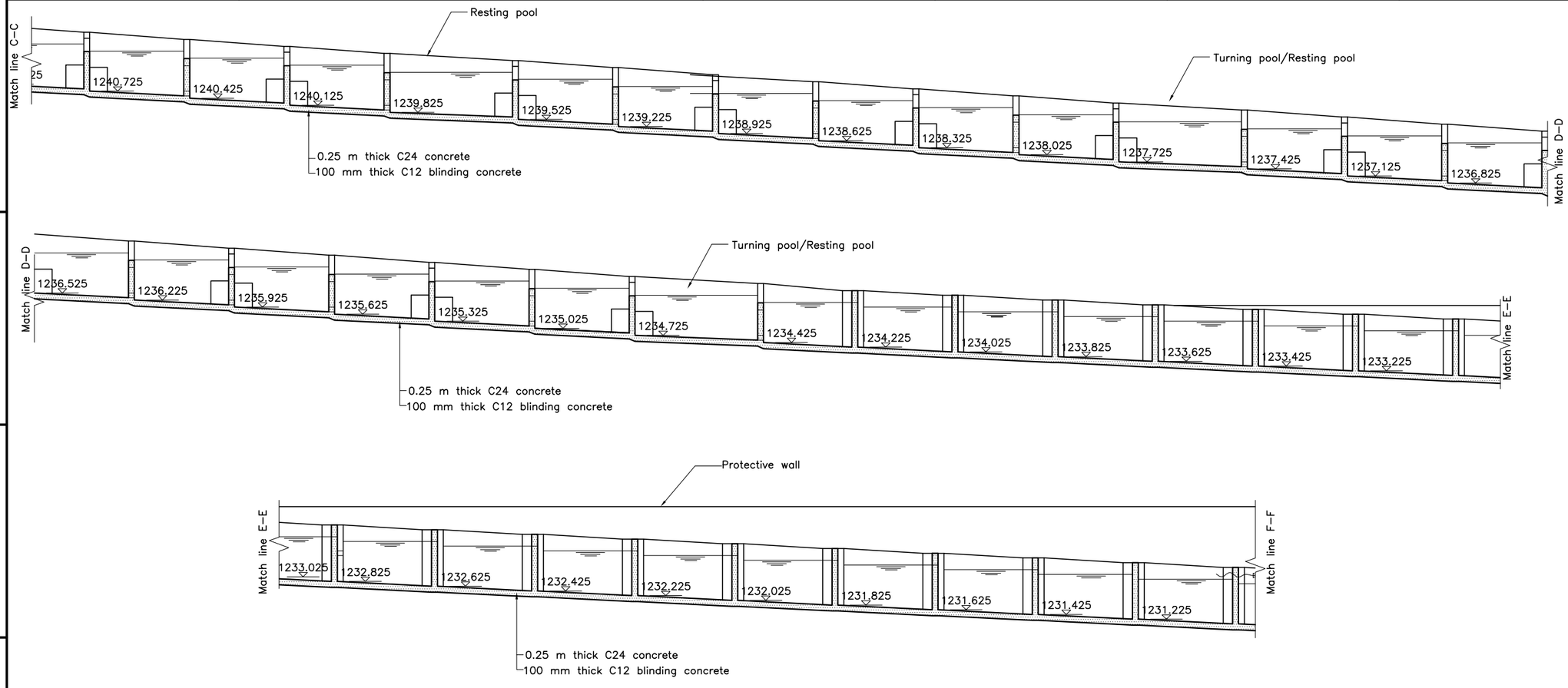
DRAWING TITLE

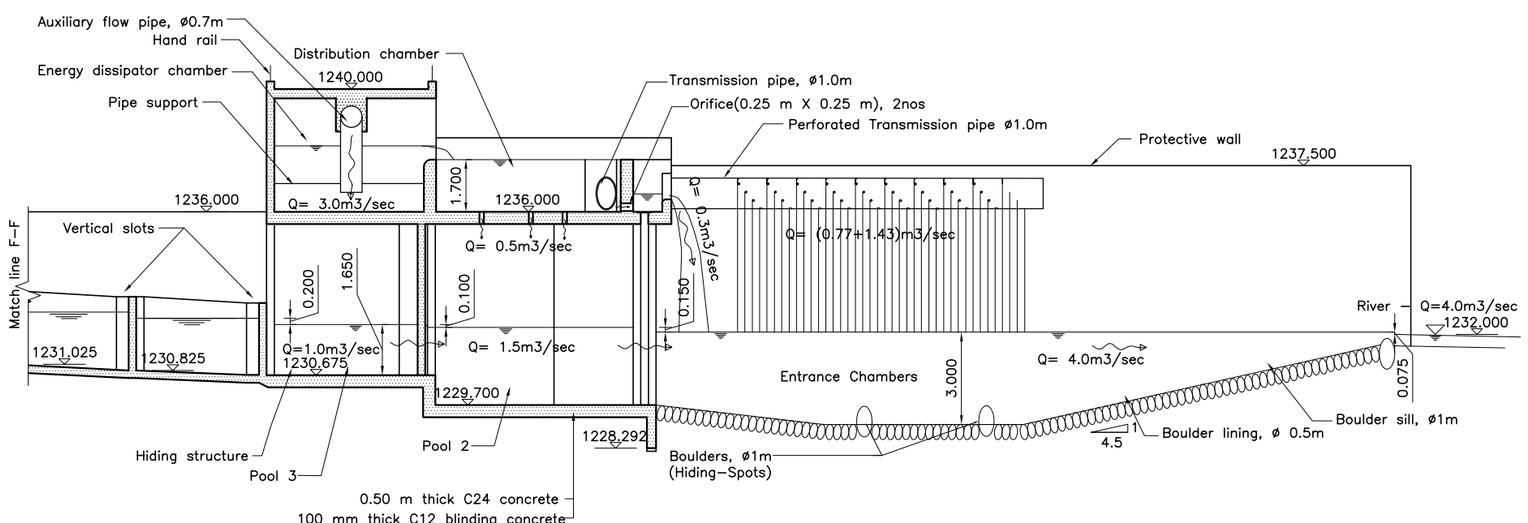
LAYOUT DRAWING OF FISH LADDER

PROFILE

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–02	02 OF 19	0A

A3 (297 x 420 mm)





LONGITUDINAL PROFILE OF FISH LADDER

Scale 1:200

NOTE

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m 2 0 2 4 6 8 m

Scale 1:200

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0A	10.NOV.2023	For Information	ShG/SaP/DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli-1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGINEERING, jade CONSULT

CONTRACTOR

DOOSAN Enerbility

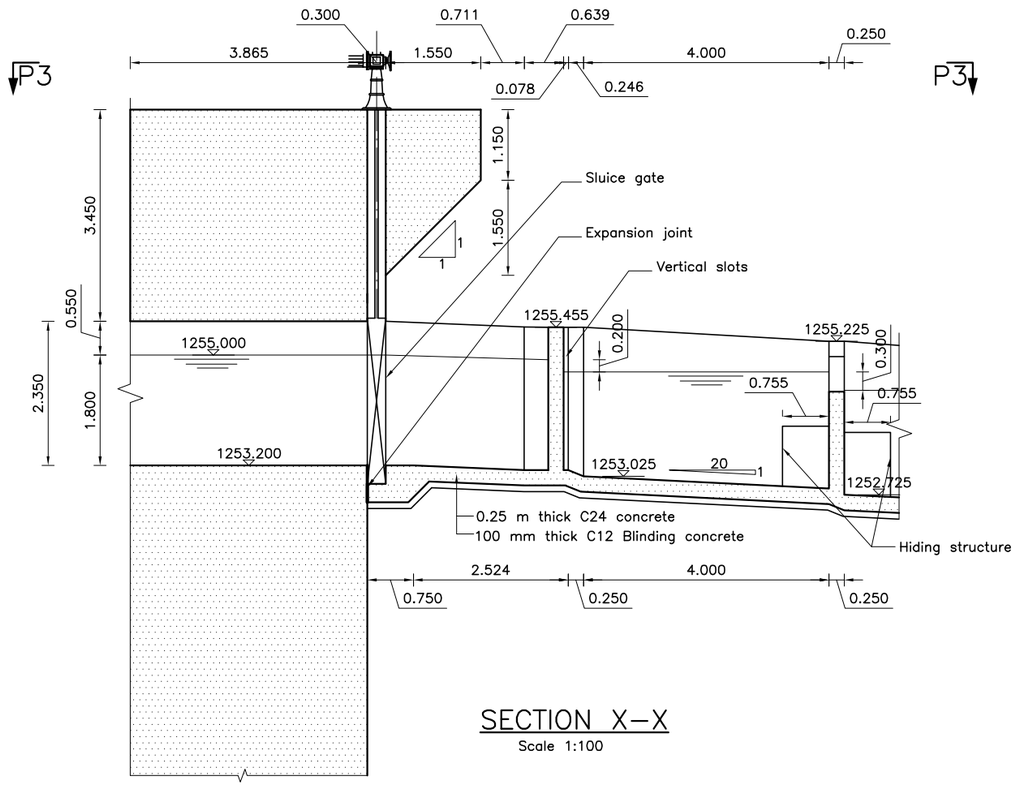
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

PROFILE

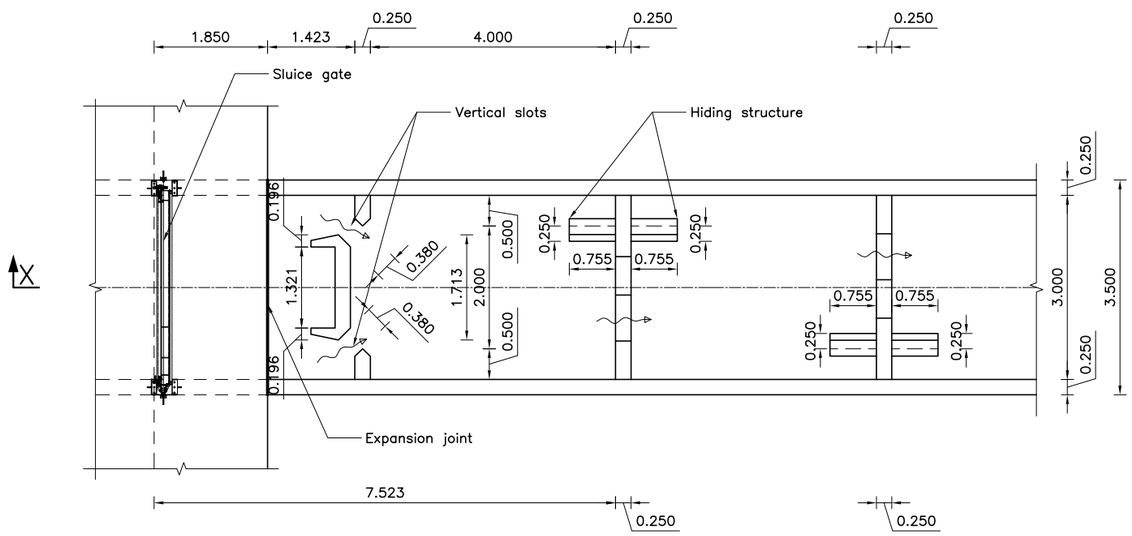
DRAWING NUMBER	SHEET NO.	REV. NO.
UT1-C-050-CVL-DG-49001-03	03 OF 19	0A

A3 (297 x 420 mm)



SECTION X–X

Scale 1:100



PLAN P3–P3

Scale 1:100

NOTE

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6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
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0A	10.NOV.2023	For Information	ShG/SaP/ DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGINEERING | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

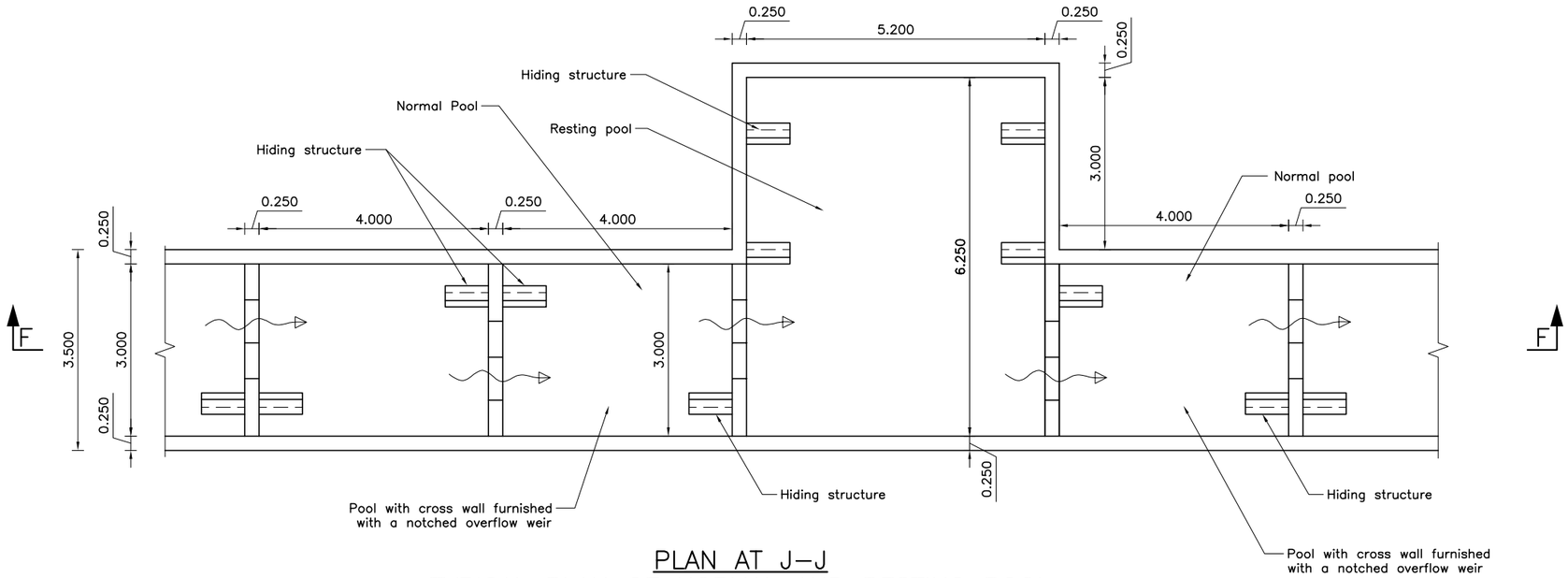
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

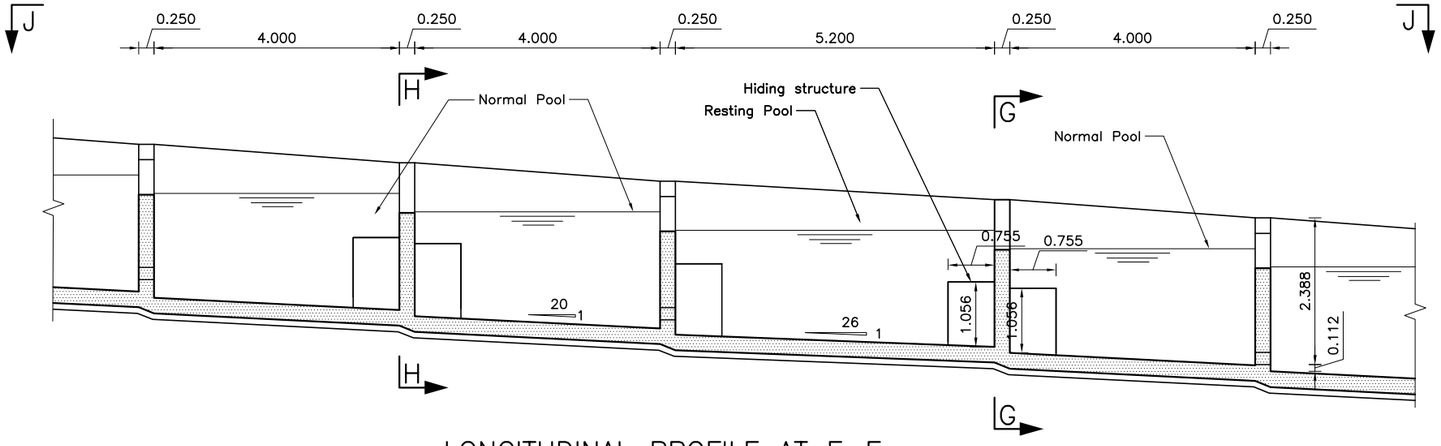
PLAN AND SECTION

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–04	04 OF 19	0A

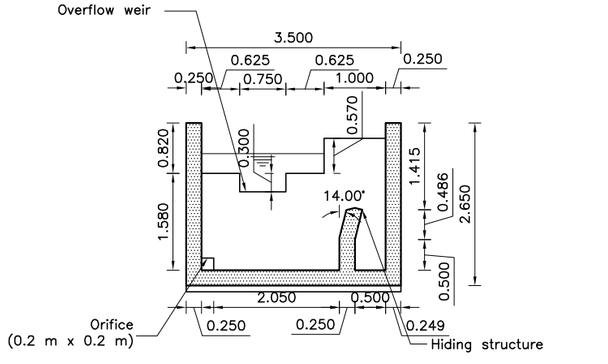
A3 (297 x 420 mm)



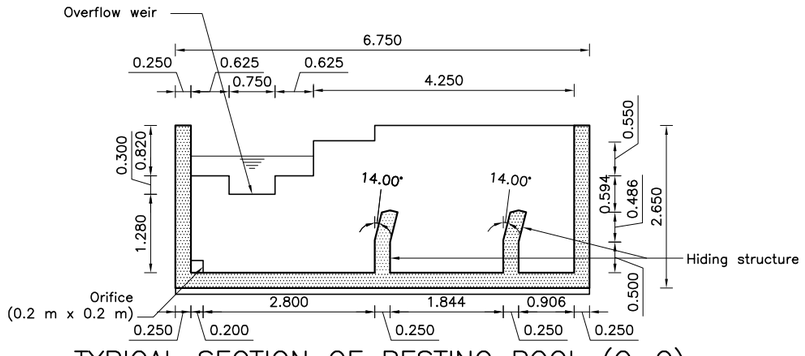
PLAN AT J–J
TYPICAL PLAN OF NORMAL AND RESTING POOL
Scale 1:100



LONGITUDINAL PROFILE AT F–F
Scale 1:100



TYPICAL SECTION OF NORMAL POOL (H–H)
Scale 1:100



TYPICAL SECTION OF RESTING POOL (G–G)
Scale 1:100

NOTE

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m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

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0A	10.NOV.2023	For Information	ShG/SaP/ DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL jade CONSULT

CONTRACTOR

DOOSAN Enerbility

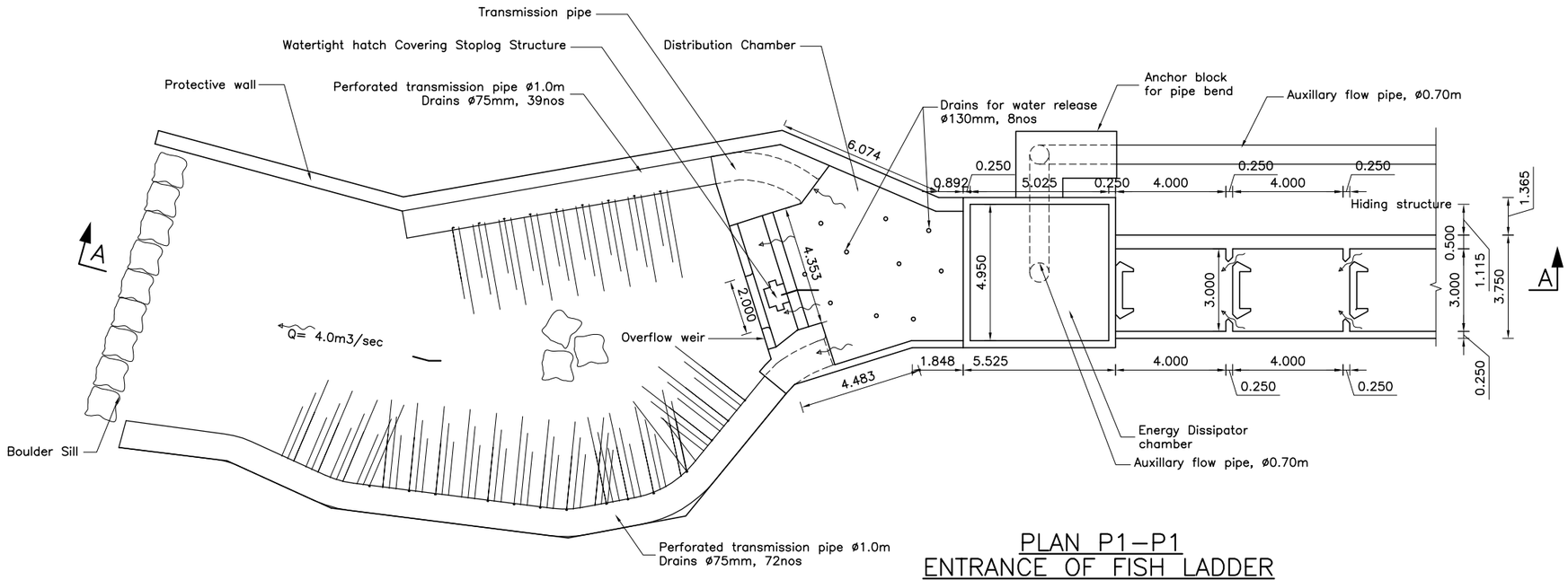
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

PLAN PROFILE AND SECTIONS

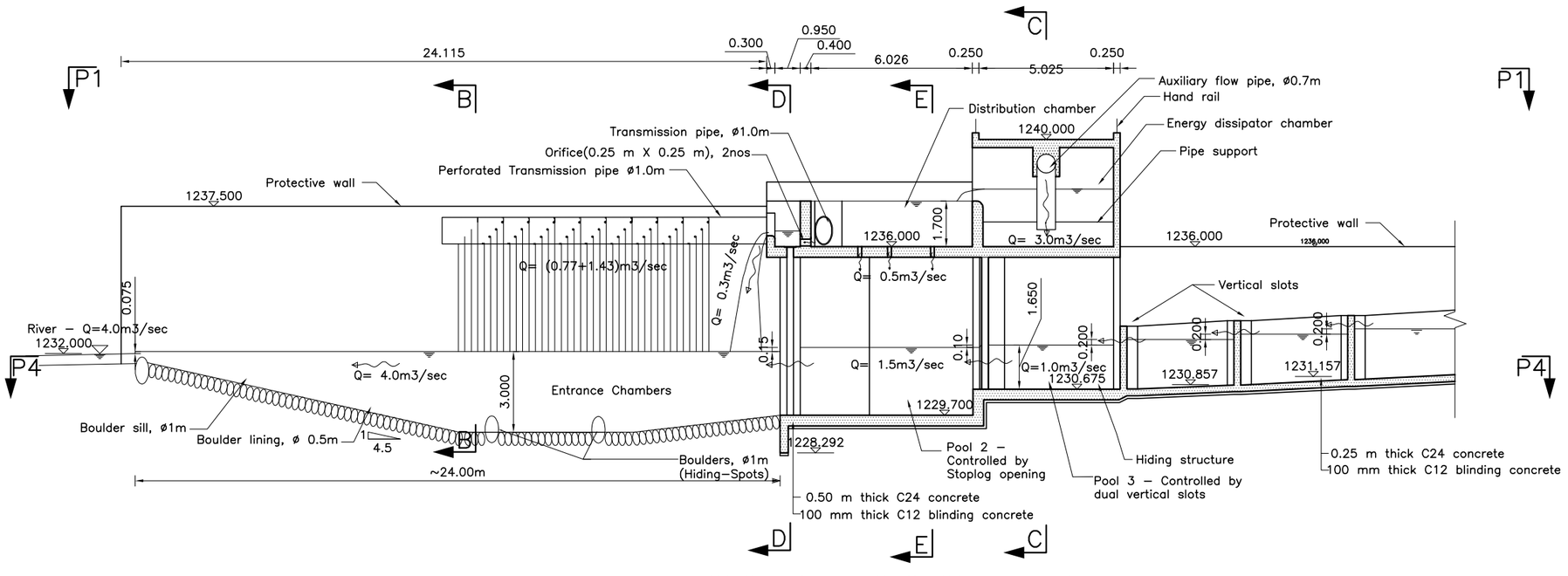
DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–05	05 OF 19	0A

A3 (297 x 420 mm)



PLAN P1–P1
ENTRANCE OF FISH LADDER
DOWNSTREAM

Scale 1:200



LONGITUDINAL SECTION AT A–A

Scale 1:200

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 2 0 2 4 8 10m

Scale 1:200

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

FOR INFORMATION

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	SHG/SaP/DIS/DIP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER: NWEDC

OWNER'S ENGINEER: TRACTEBEL, jade CONSULT

CONTRACTOR: DOOSAN Enerbility

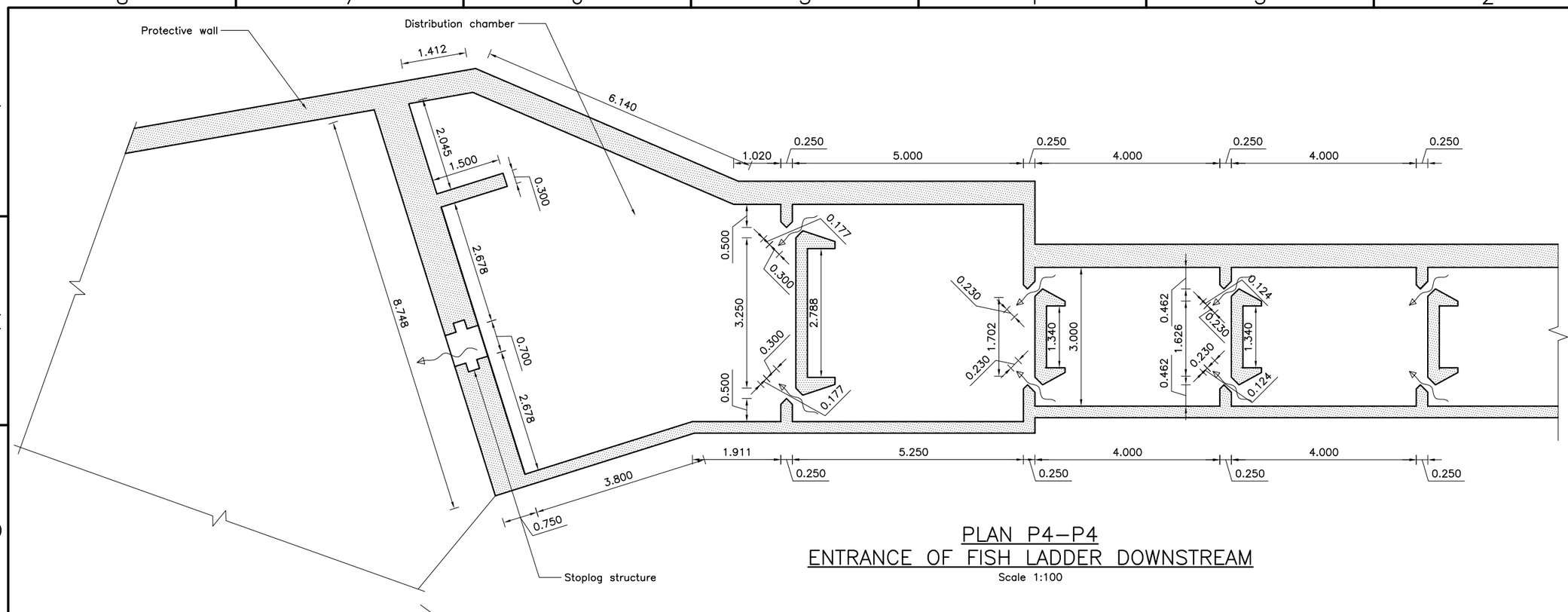
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

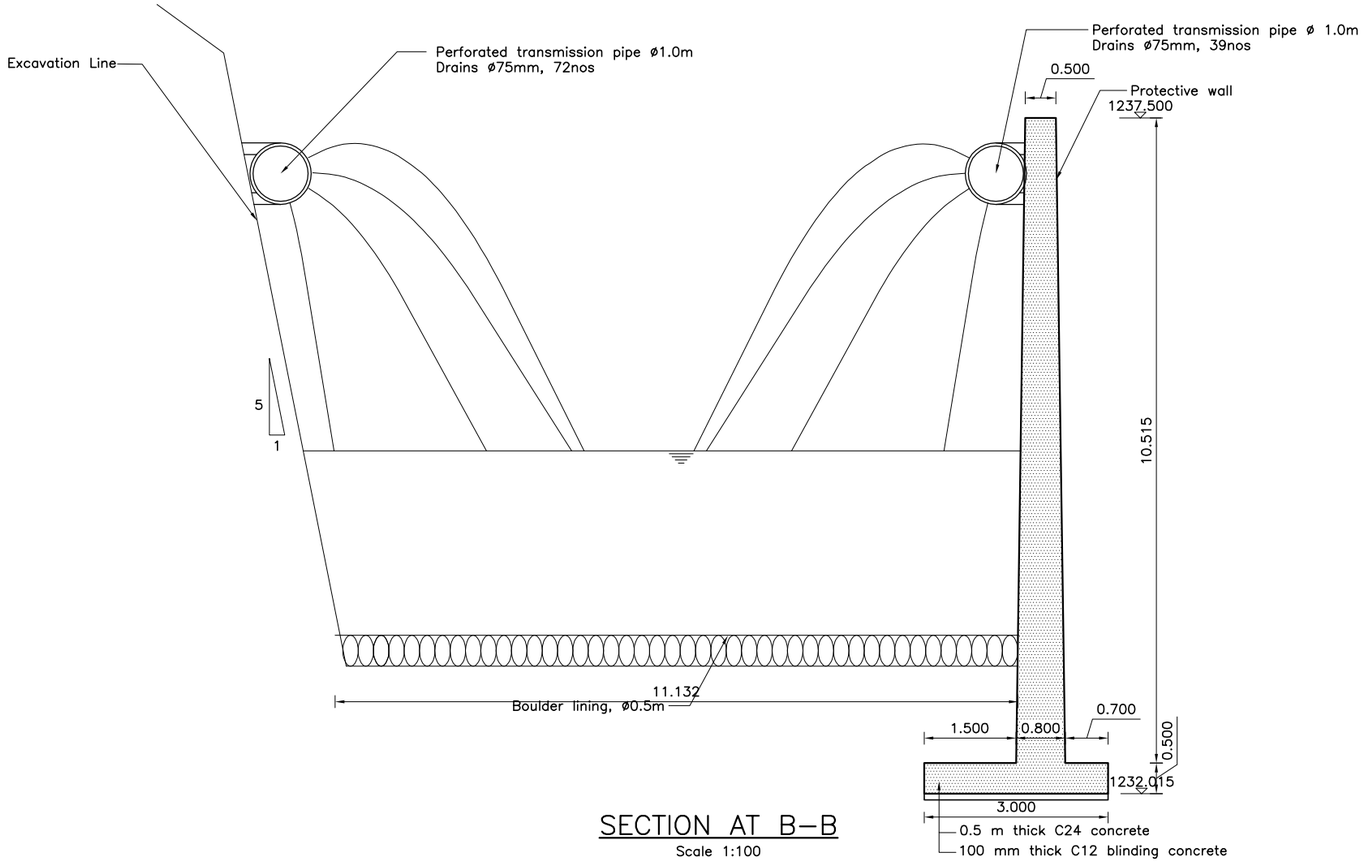
PLAN AND SECTION

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–06	06 OF 19	0B

A3 (297 x 420 mm)



PLAN P4–P4
ENTRANCE OF FISH LADDER DOWNSTREAM
Scale 1:100



SECTION AT B–B
Scale 1:100

NOTE

1. All dimensions are in m, levels are in m above msl unless otherwise mentioned.
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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/ DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGINEERING, jade CONSULT

CONTRACTOR

DOOSAN Enerbility

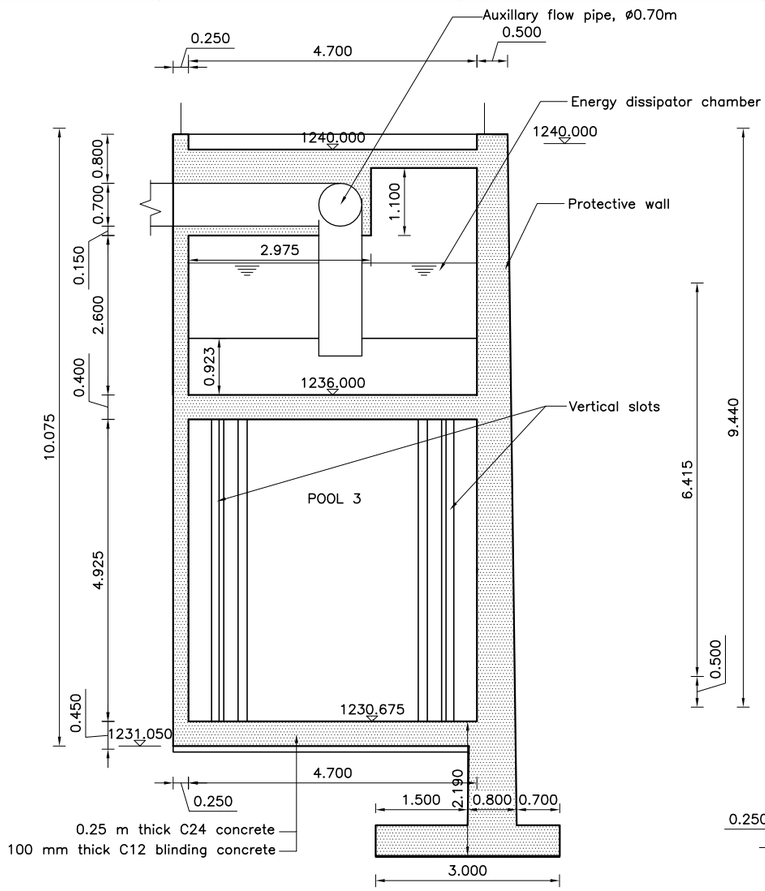
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

PLAN AND SECTION

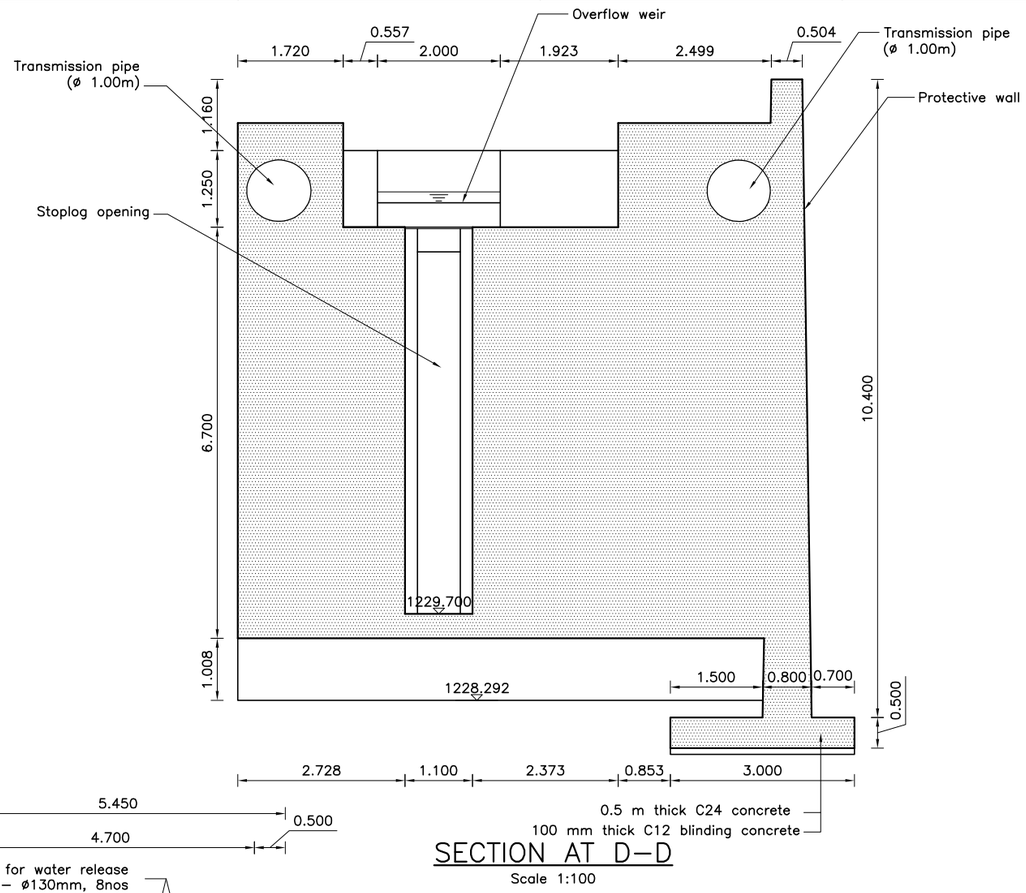
DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–07	07 OF 19	0B

A3 (297 x 420 mm)



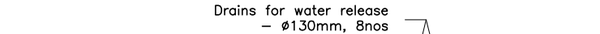
SECTION AT C–C

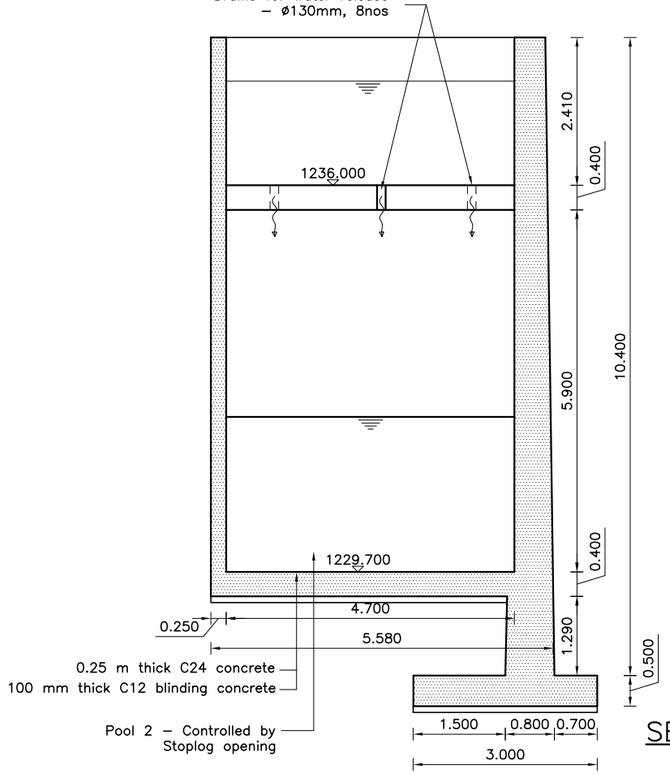
Scale 1:100



SECTION AT D–D

Scale 1:100





SECTION AT E–E

Scale 1:100

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

FOR INFORMATION

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL jade CONSULT

CONTRACTOR

DOOSAN Enerbility

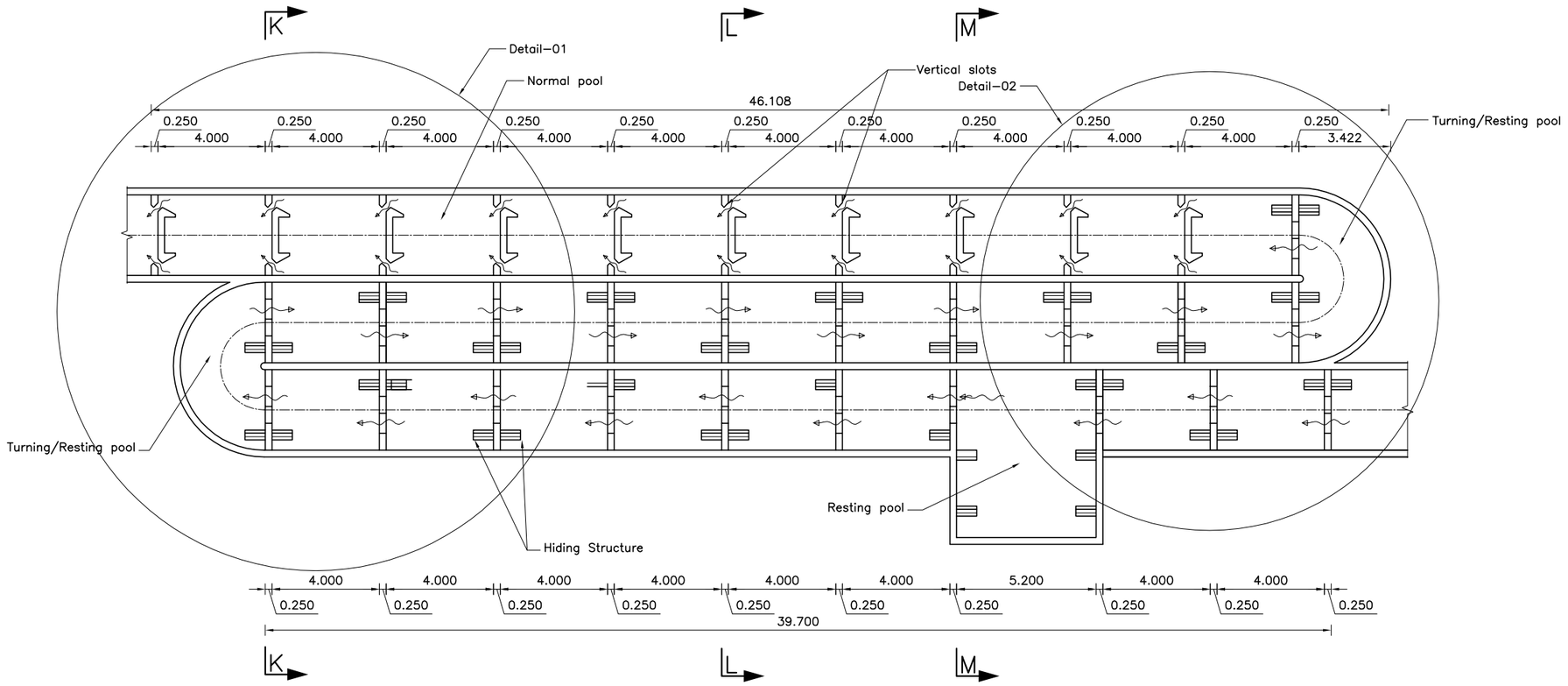
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

SECTIONS

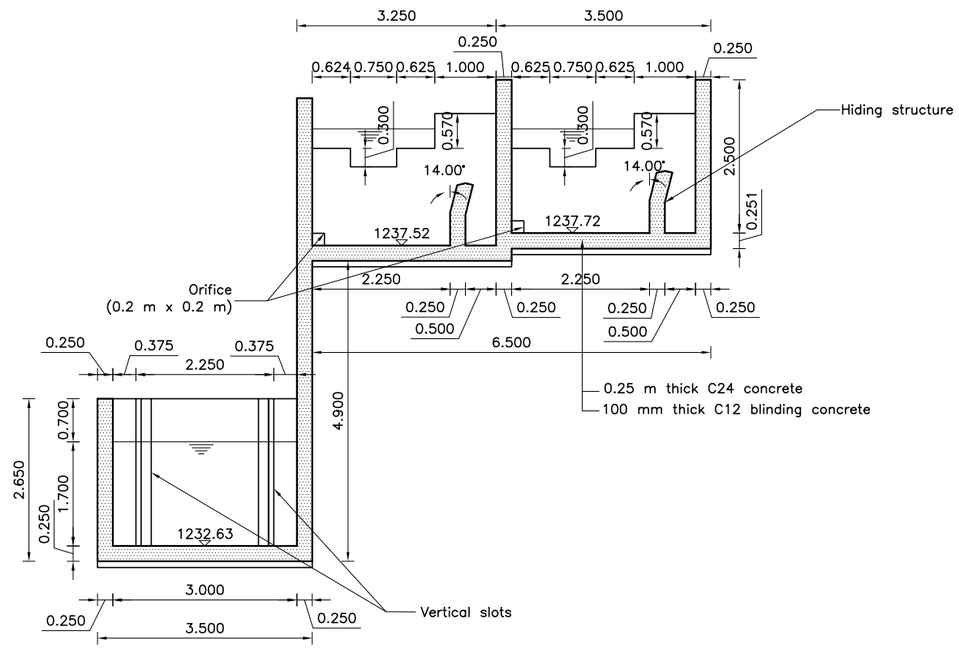
DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–08	08 OF 19	0A

A3 (297 x 420 mm)



PLAN P2–P2 (SERPENTINE PART)

Scale 1:200



SECTION AT K–K

Scale 1:100

NOTE

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2. The size of the upstream and downstream fish ladders are based on the hydraulic sizing. The actual thickness of the walls and base slab shall be finalized after the structural design.
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6. Hydro mechanical structures shown in drawing are only for reference.

m1 0 1 2 3 4 m

Scale 1:100

m2 0 2 4 6 8 m

Scale 1:200

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC NEPAL WATER AND ENERGY DEVELOPMENT CO. (PVT) LTD.

OWNER'S ENGINEER

TRACTEBEL ENGINEERING — jade CONSULT

CONTRACTOR

DOOSAN Enerbility

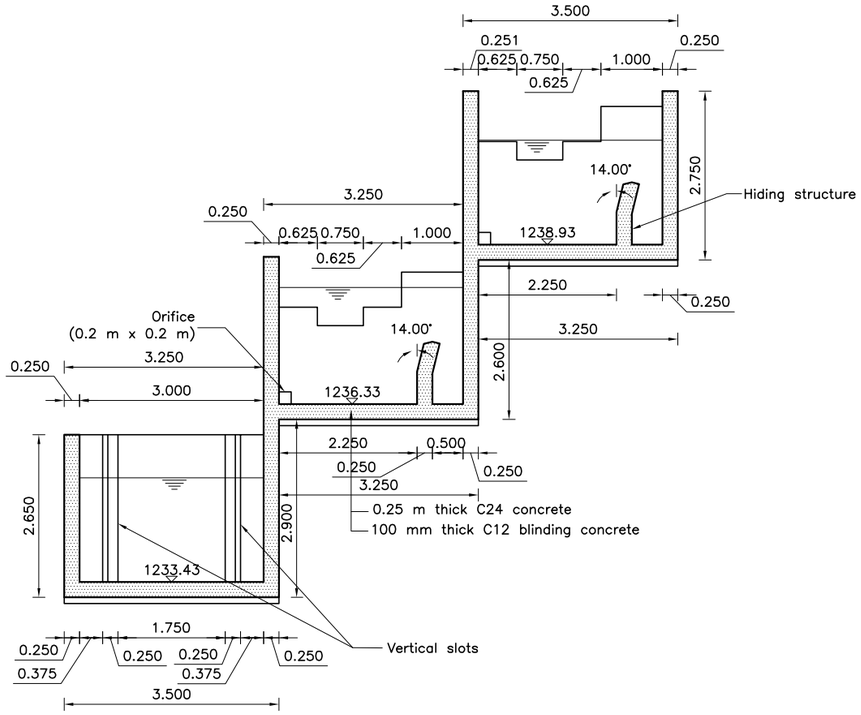
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

PLAN AND SECTION

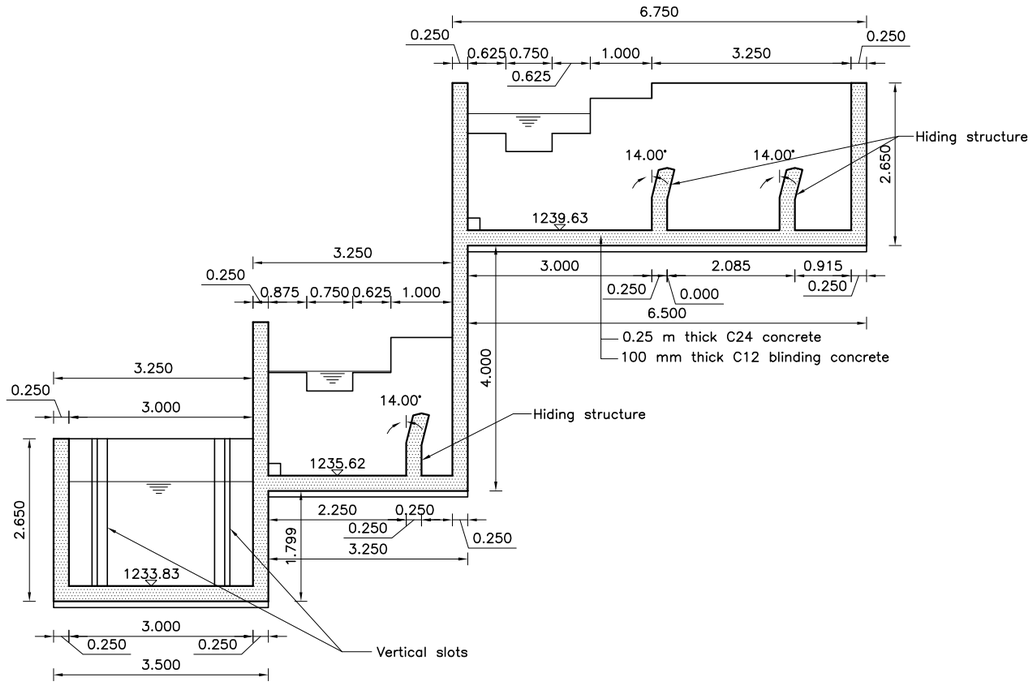
DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–09	09 OF 19	0A

A3 (297 x 420 mm)



SECTION AT L–L

Scale 1:100



SECTION AT M–M

Scale 1:100

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL jade CONSULT

CONTRACTOR

DOOSAN Enerbility

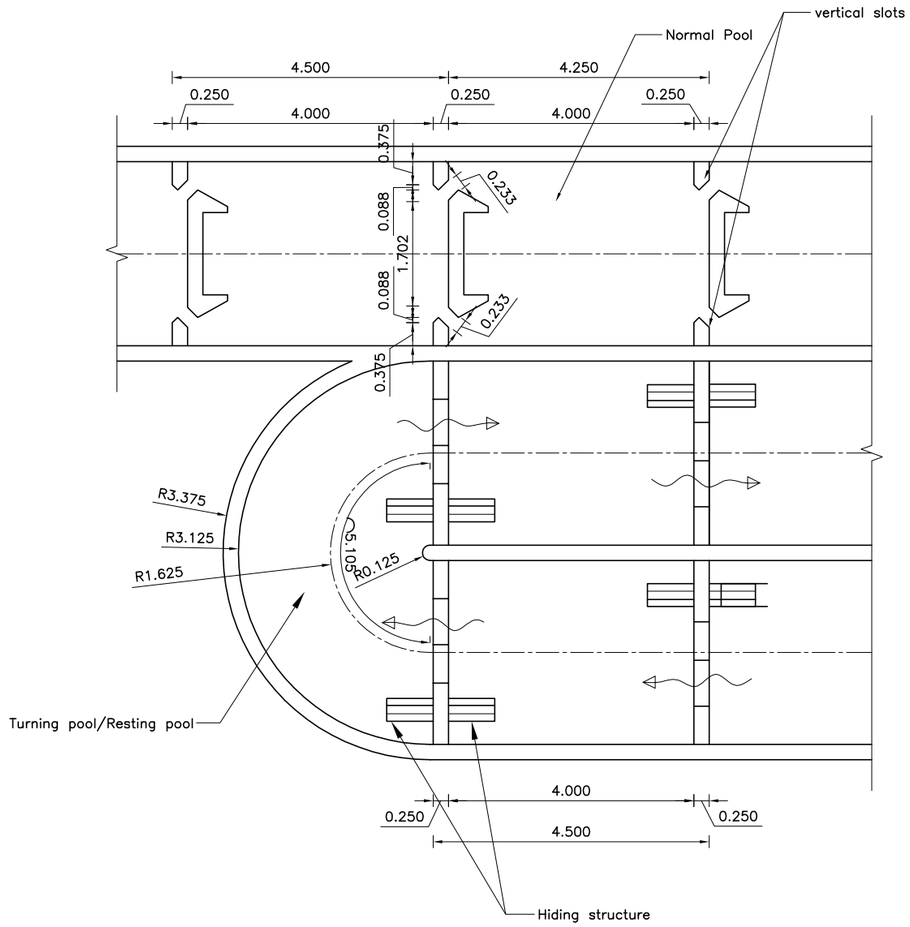
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

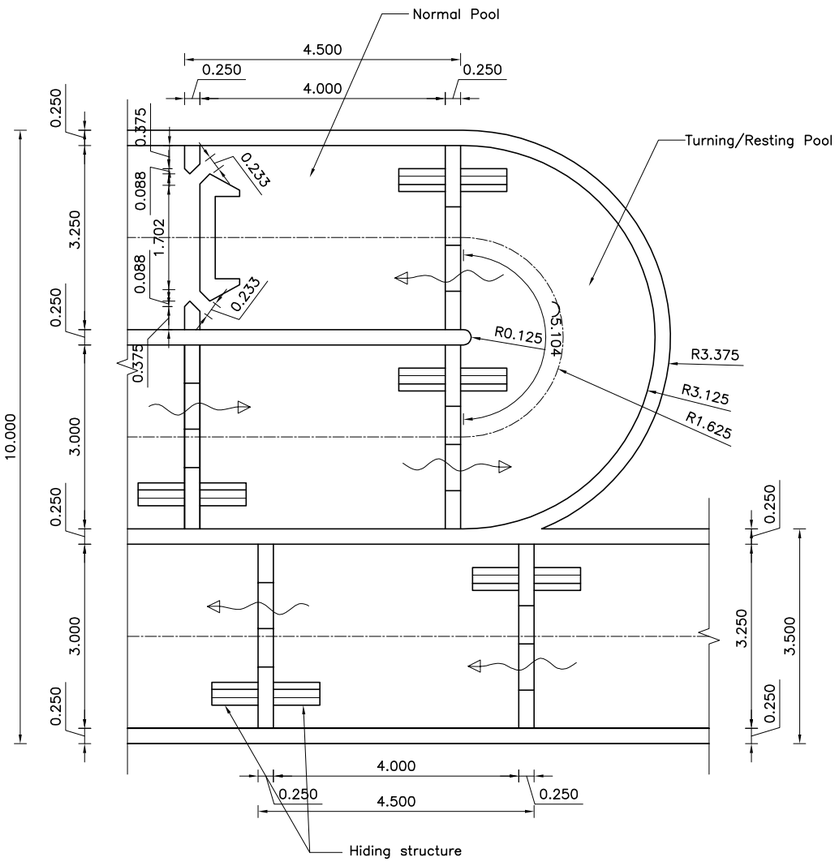
SECTIONS

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–10	10 OF 19	0A

A3 (297 x 420 mm)



DETAIL–01
Scale 1:100



DETAIL–02
Scale 1:100

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC NEPAL WATER AND ENERGY DEVELOPMENT CO. PVT. LTD.

OWNER'S ENGINEER

TRACTEBEL ENGINEERING | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

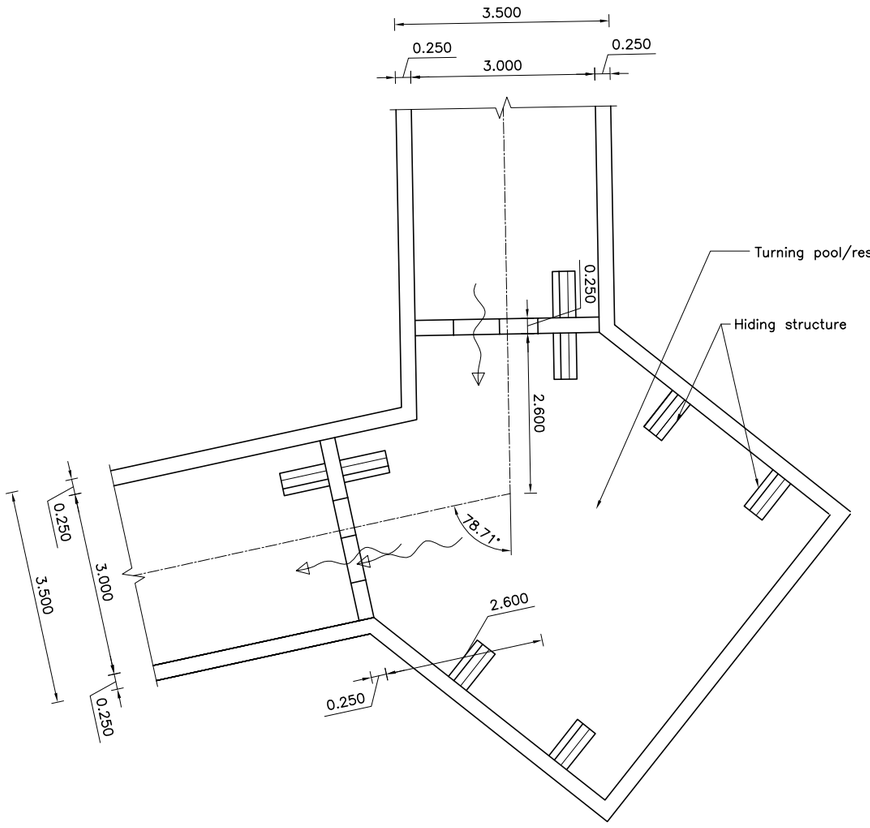
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

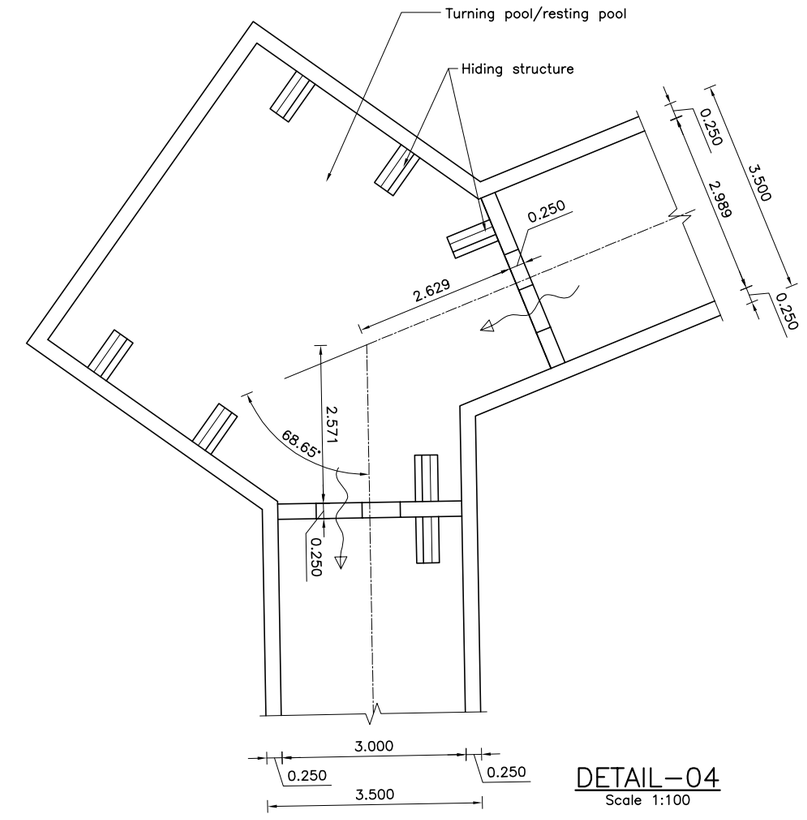
DETAILS

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–11	11 OF 19	0A

A3 (297 x 420 mm)



DETAIL–03
Scale 1:100



DETAIL–04
Scale 1:100

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/DIS/DIP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL jade CONSULT

CONTRACTOR

DOOSAN Enerbility

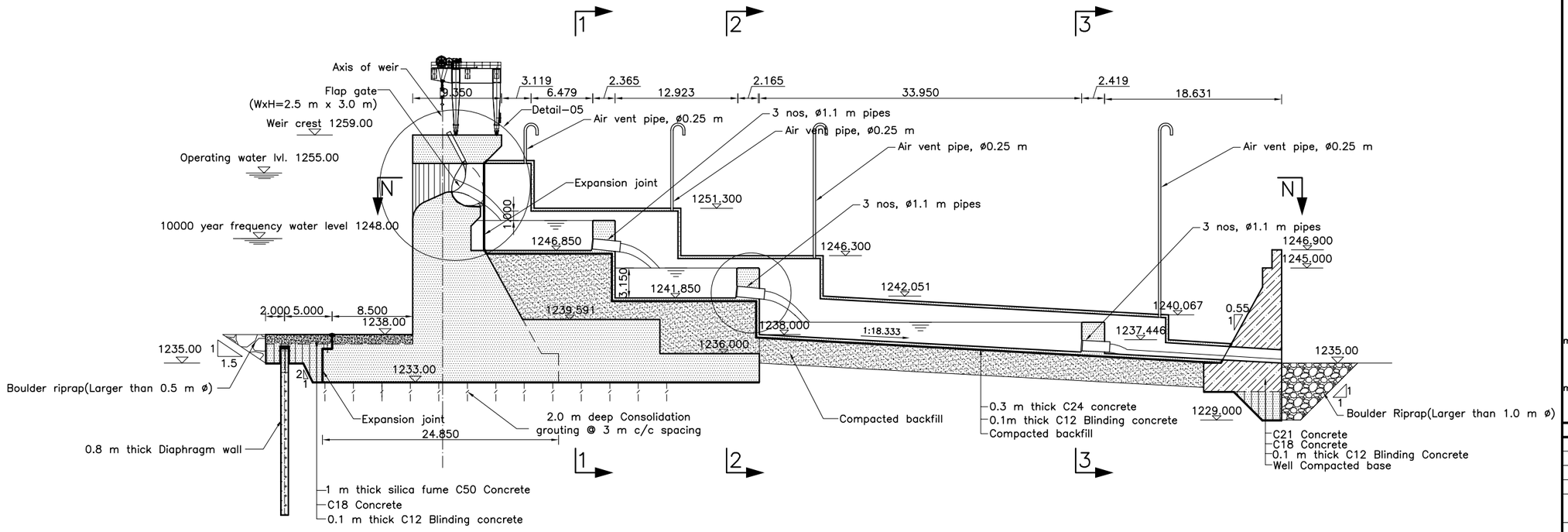
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

DETAILS

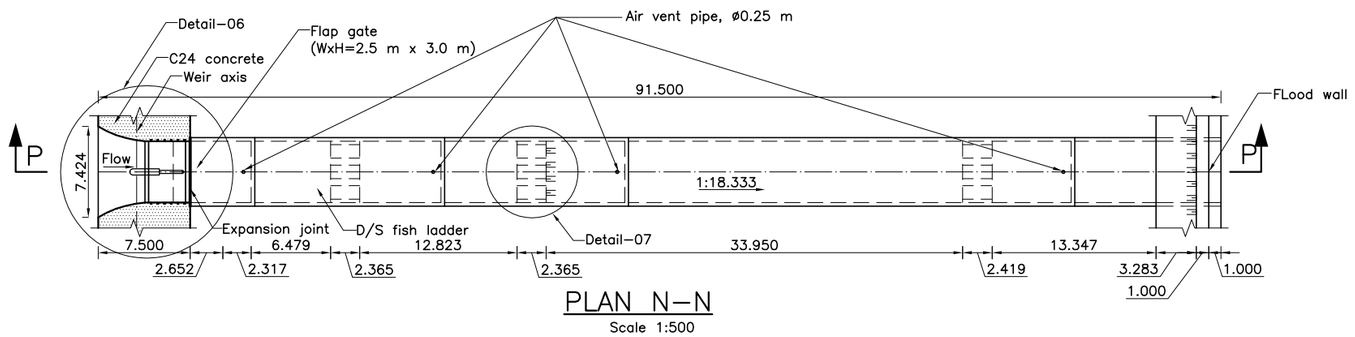
DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–12	12 OF 19	0A

A3 (297 x 420 mm)



LONGITUDINAL PROFILE P–P OF D/S FISH LADDER

Scale 1:500



PLAN N–N

Scale 1:500

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 5 0 5 10 15 20m

Scale=1:500

m 2 0 2 4 6 8 m

Scale=1:200

REFERENCE DRAWINGS

UT1-C-020-CVL-DG-44004-0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/ DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli-1 HEP (216 MW)

OWNER

NWEDC NEPAL WATER AND ENERGY DEVELOPMENT CO. PVT. LTD.

OWNER'S ENGINEER

TRACTEBEL Engie | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

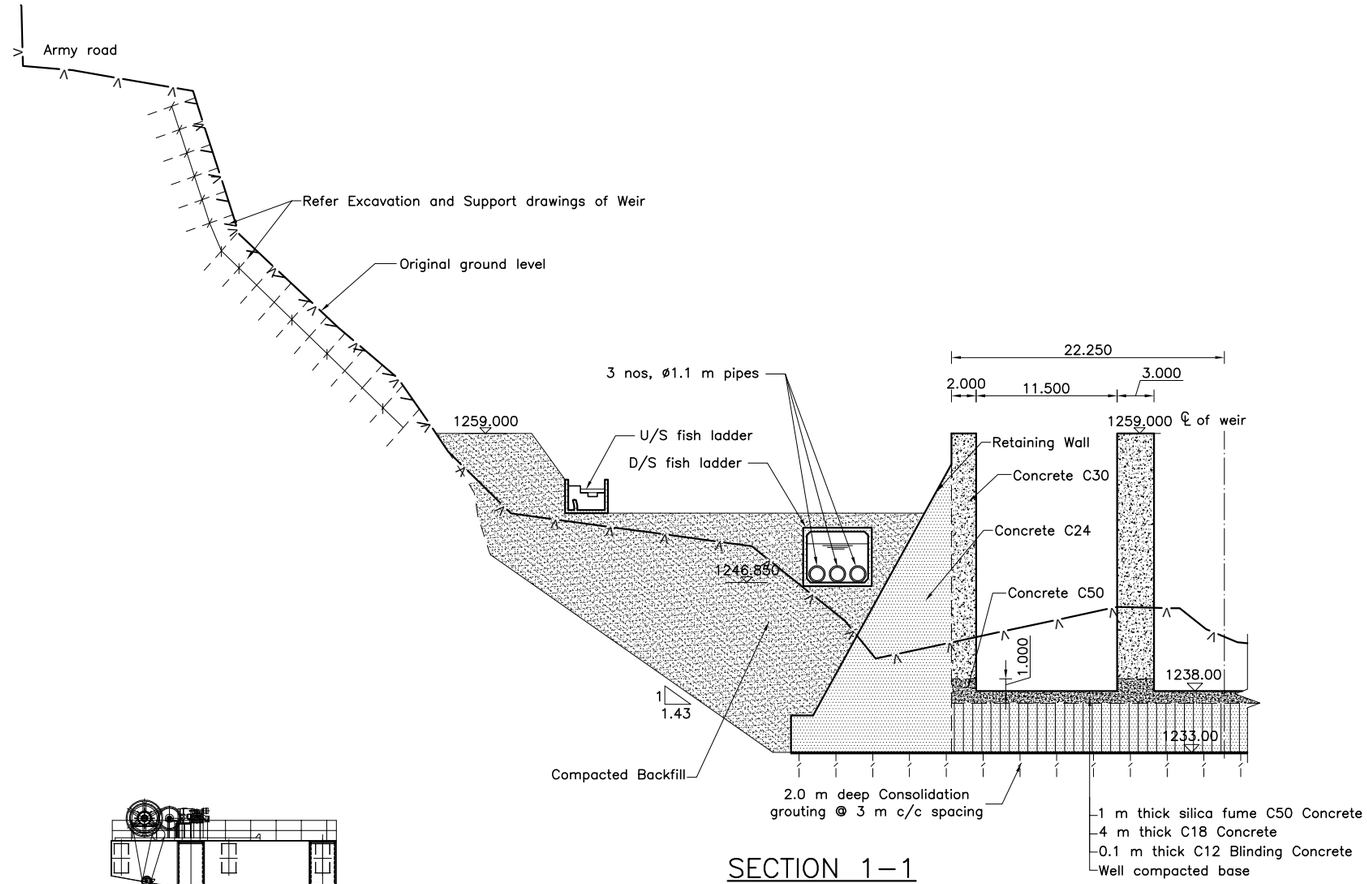
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

PLAN AND PROFILE

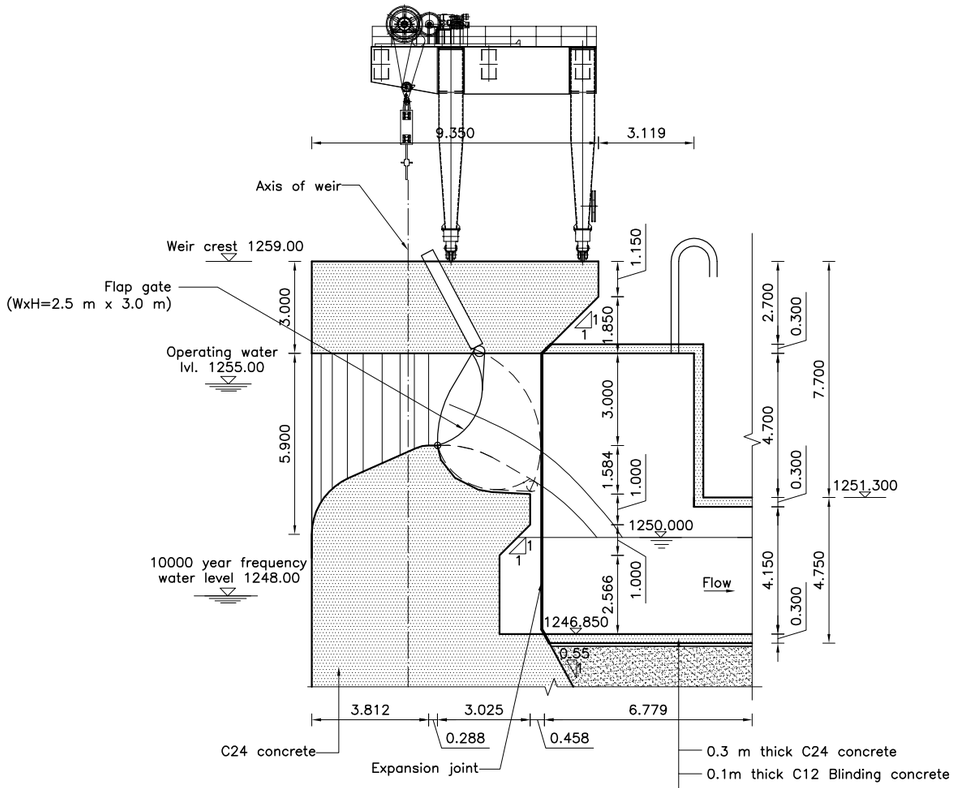
DRAWING NUMBER	SHEET NO.	REV. NO.
UT1-C-050-CVL-DG-49001-13	13 OF 19	0A

A3 (297 x 420 mm)



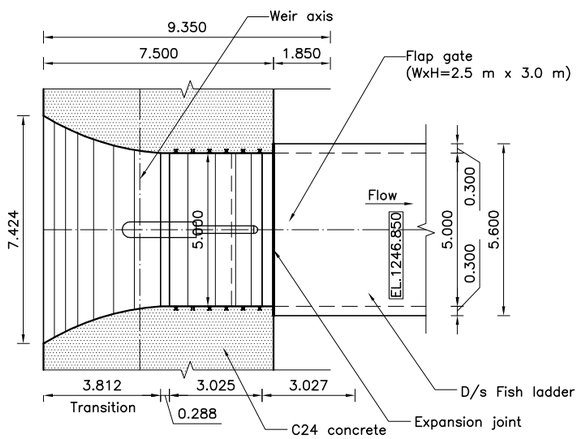
SECTION 1–1

Scale 1:500



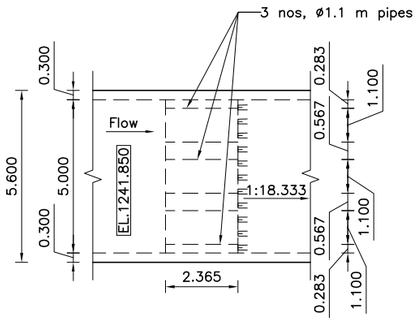
DETAIL–05

Scale 1:200



DETAIL–06

Scale 1:200



DETAIL–07

Scale 1:200

NOTE

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4. The arrangement of the auxiliary flow pipe and anchor block is subjected to change as per the structural design of the fish ladder.
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6. Hydro mechanical structures shown in drawing are only for reference.

m 5 0 5 10 15 20m

Scale=1:500

m 2 0 2 4 6 8 m

Scale=1:200

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

FOR INFORMATION

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/ DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGINEERING, jade CONSULT

CONTRACTOR

DOOSAN Enerbility

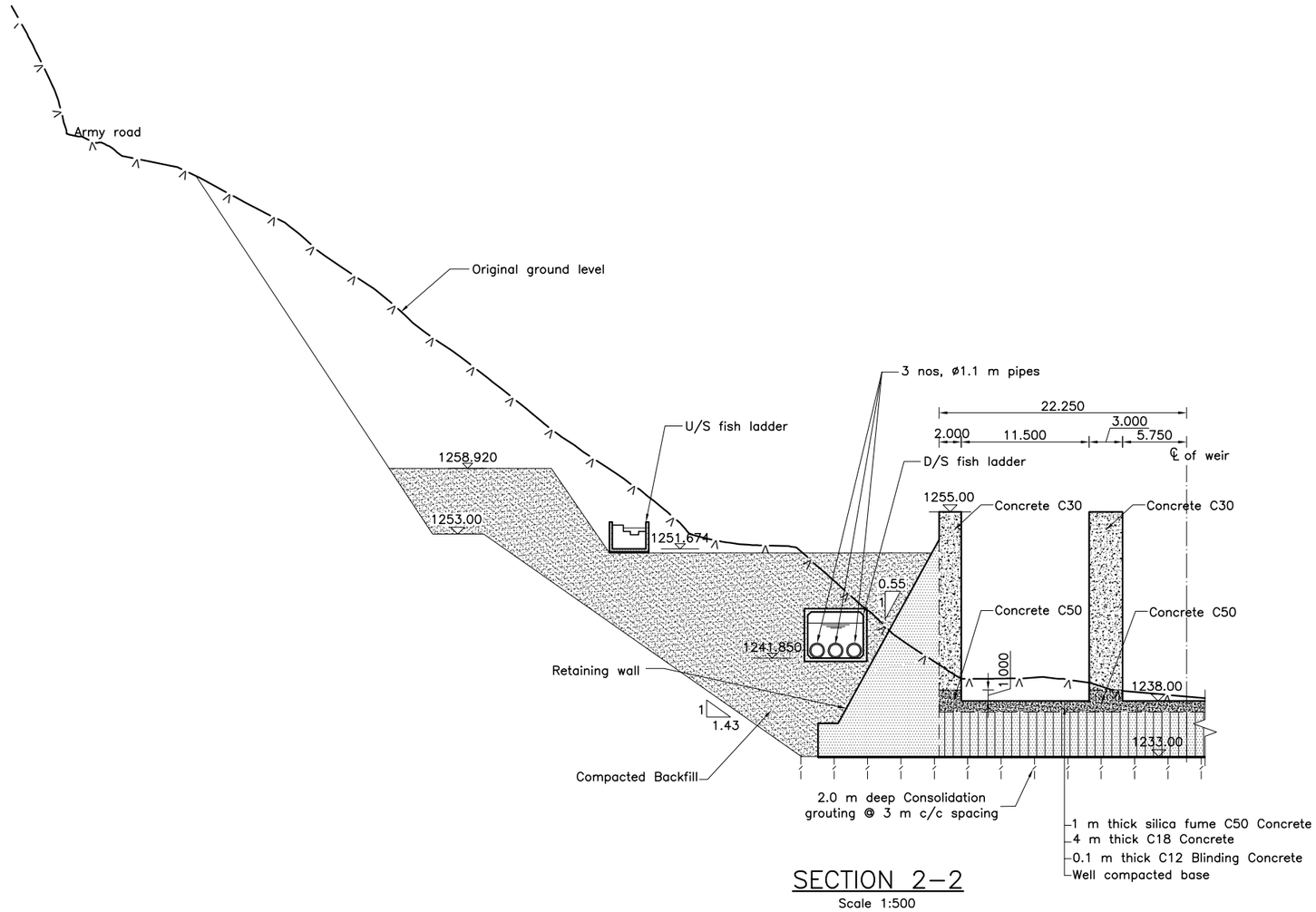
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

SECTION AND DETAILS

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–14	14 OF 19	0A

A3 (297 x 420 mm)



SECTION 2–2

Scale 1:500

NOTE

1. All dimensions are in m, levels are in m above msl unless otherwise mentioned.
2. The size of the upstream and downstream fish ladders are based on the hydraulic sizing. The actual thickness of the walls and base slab shall be finalized after the structural design.
3. The flood wall arrangement provided adjacent to entrance pool of upstream fish ladder(at the left bank of river) is only for reference. the actual size of the wall shall be finalized after design.
4. The arrangement of the auxiliary flow pipe and anchor block is subjected to change as per the structural design of the fish ladder.
5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 5 0 5 10 15 20m

Scale 1:500

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGIE | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

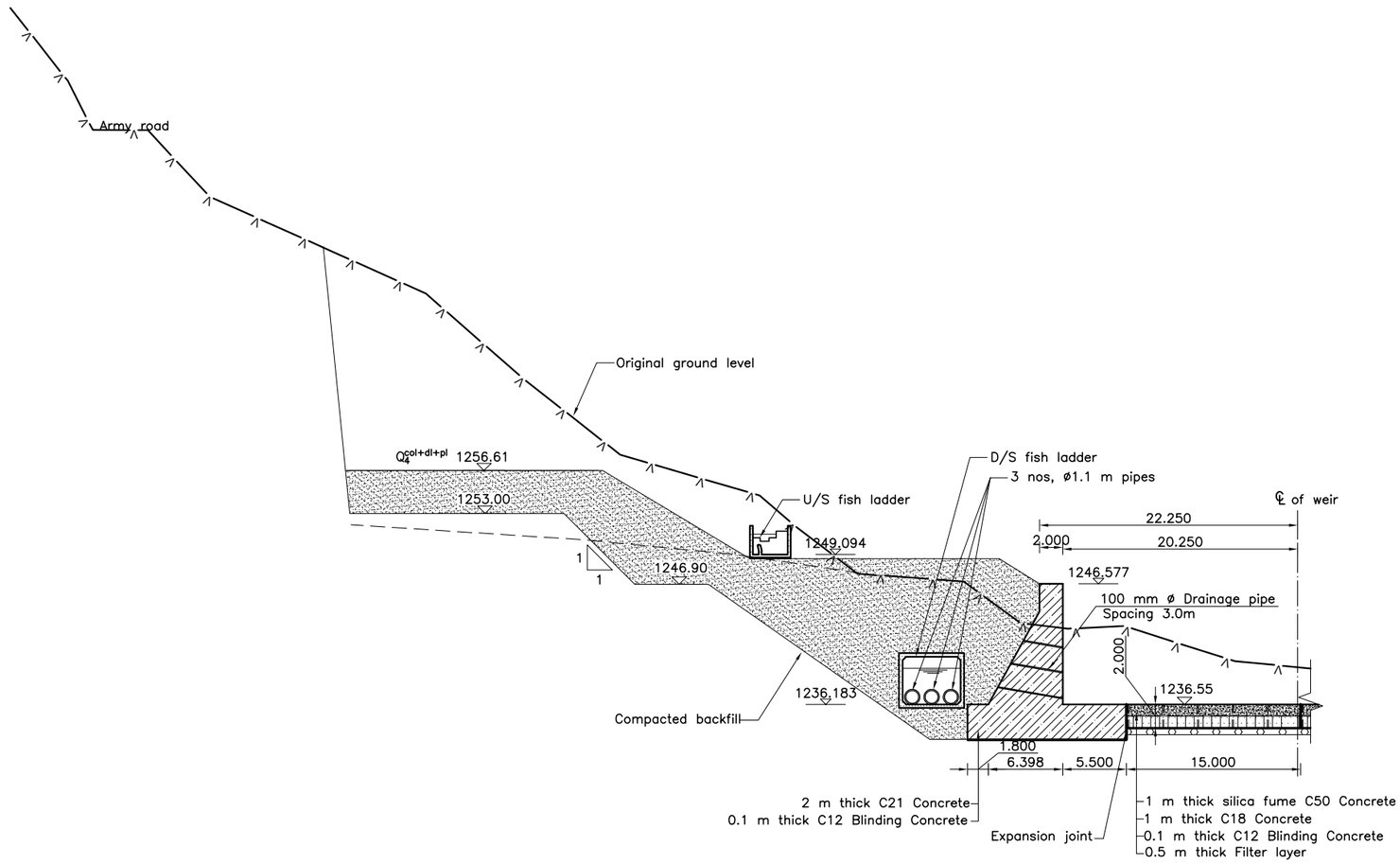
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

SECTION

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–15	15 OF 19	0A

A3 (297 x 420 mm)



SECTION 3–3

Scale 1:500

NOTE

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2. The size of the upstream and downstream fish ladders are based on the hydraulic sizing. The actual thickness of the walls and base slab shall be finalized after the structural design.
3. The flood wall arrangement provided adjacent to entrance pool of upstream fish ladder(at the left bank of river) is only for reference. the actual size of the wall shall be finalized after design.
4. The arrangement of the auxiliary flow pipe and anchor block is subjected to change as per the structural design of the fish ladder.
5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 5 0 5 10 15 20m

Scale 1:500

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/ DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGIE | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

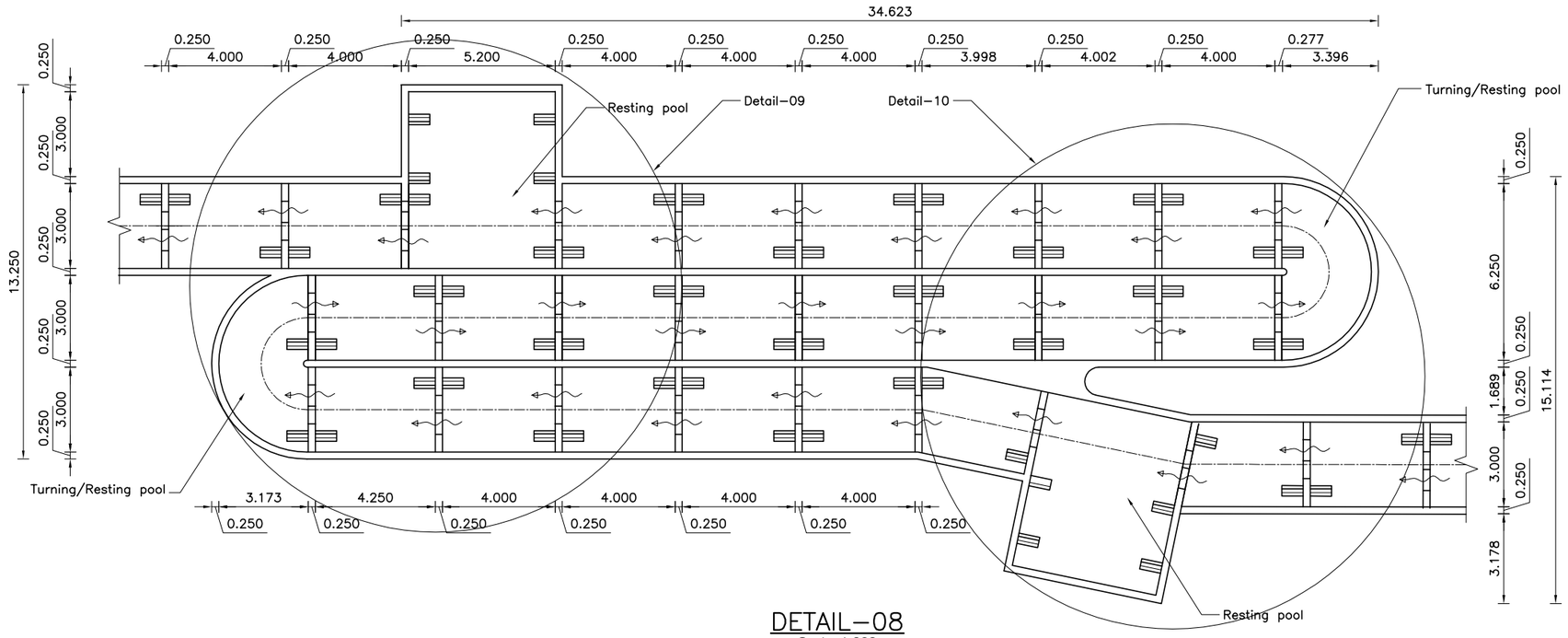
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

SECTION

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–16	16 OF 19	0A

A3 (297 x 420 mm)



DETAIL–08

Scale 1:200

NOTE

1. All dimensions are in m, levels are in m above msl unless otherwise mentioned.
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4. The arrangement of the auxiliary flow pipe and anchor block is subjected to change as per the structural design of the fish ladder.
5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 2 0 2 4 8 10m

Scale 1:200

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

- C24/Primary Concreting
- Backfill
- C21 Concrete
- Elevation lines
- C30 Concrete
- C50 Concrete
- C18 Concrete
- Section lines

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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	ShG/SaP/DiS/DiP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC

OWNER'S ENGINEER

TRACTEBEL ENGIE | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

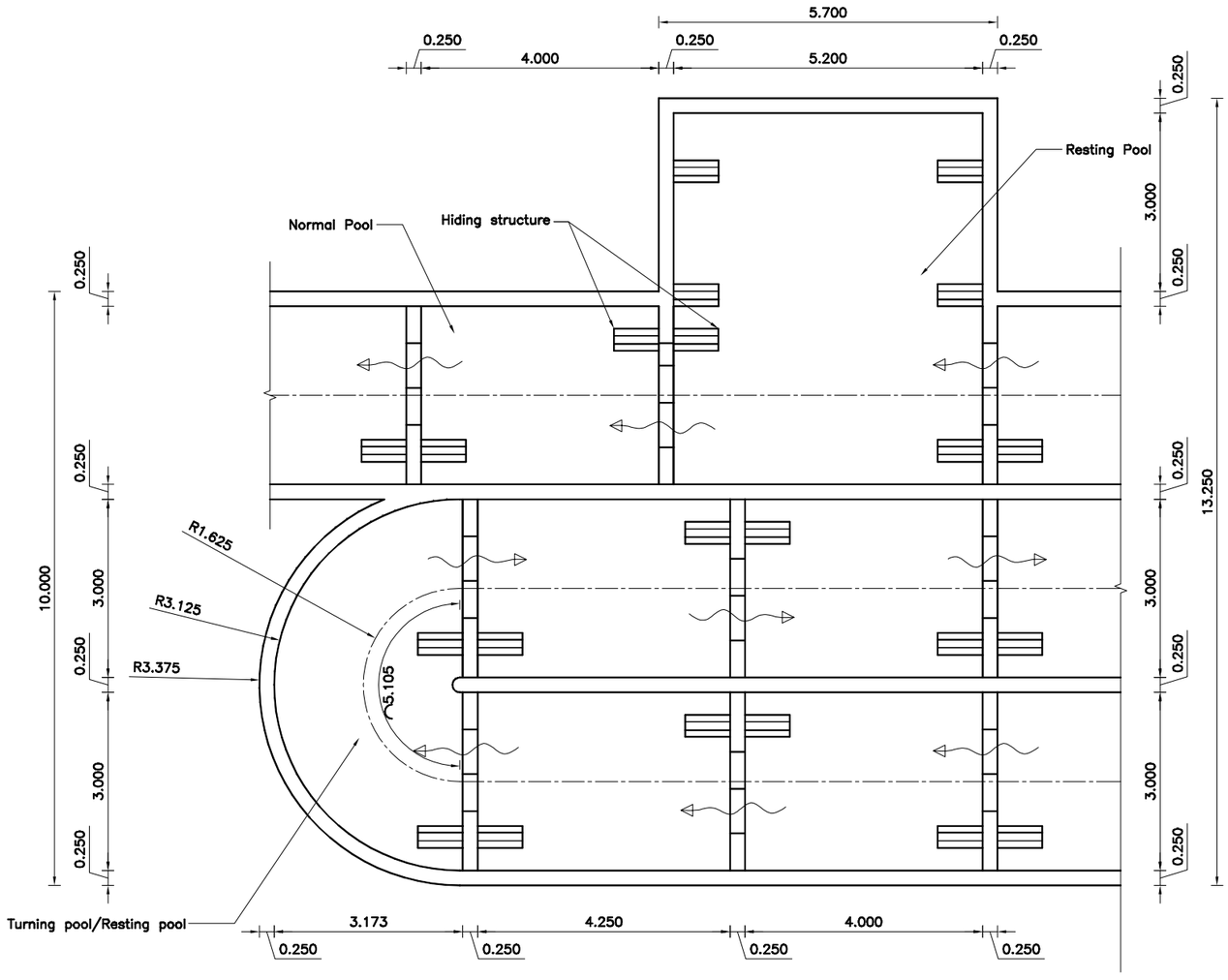
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

PLAN

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–06	17 OF 19	0B

A3 (297 x 420 mm)



DETAIL–09

Scale 1:100

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

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- Elevation lines
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REV. NO.	DATE	DESCRIPTION	DRAWN	CHKD.	APPD.
0A	10.NOV.2023	For Information	SHG/SaP/DIS/DIP	SAJAN S.	AJOY K.

PROJECT TITLE

Upper Trishuli–1 HEP (216 MW)

OWNER

NWEDC NEPAL WATER AND ENERGY DEVELOPMENT CO. PVT. LTD.

OWNER'S ENGINEER

TRACTEBEL ENGIE | jade CONSULT

CONTRACTOR

DOOSAN Enerbility

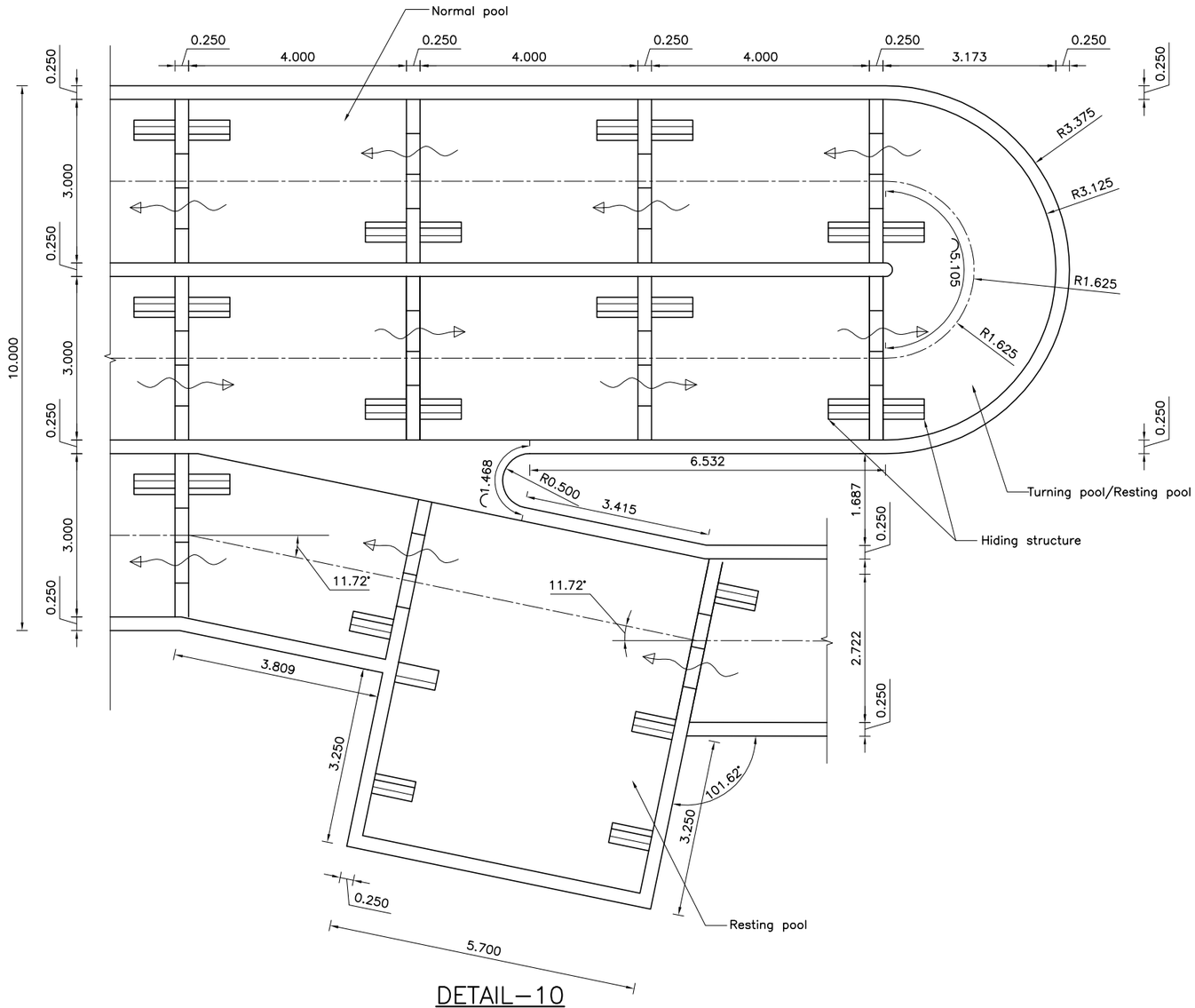
DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

DETAIL

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–18	06 OF 19	0B

A3 (297 x 420 mm)



DETAIL–10

Scale 1:100

NOTE

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5. The access road to the weir, location of the weir control building and observation room shall be finalized after the approval of the upstream and downstream fish ladder arrangement.
6. Hydro mechanical structures shown in drawing are only for reference.

m 1 0 1 2 3 4 m

Scale 1:100

REFERENCE DRAWINGS

UT1–C–020–CVL–DG–44004–0A	CONCRETE OUTLINE DRAWING OF WEIR

SYMBOL AND LEGEND

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0A	10.NOV.2023	For Information	SHG/SaP/DIS/DIP	SAJAN S.	AJOY K.

PROJECT TITLE

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OWNER

NWEDC NEPAL WATER AND ENERGY DEVELOPMENT CO. PVT. LTD.

OWNER'S ENGINEER

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DOOSAN Enerbility

DRAWING TITLE

LAYOUT DRAWING OF FISH LADDER

DETAIL

DRAWING NUMBER	SHEET NO.	REV. NO.
UT1–C–050–CVL–DG–49001–19	06 OF 19	0B

A3 (297 x 420 mm)